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In the Supreme Court of the United States

OCTOBER TERM, 1974

No. 74-1323

AUBREY E. DOUGLAS,
PLAINTIFF, PETITIONER,

v.

THE UNITED STATES,
DEFENDANT.

PETITION FOR A WRIT OF CERTIORARI TO REVIEW A DECISION OF THE UNITED STATES COURT OF CLAIMS

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PETITION FOR A WRIT OF CERTIORARI TO REVIEW A DECISION OF THE UNITED STATES COURT OF CLAIMS

The Petitioner, Aubrey E. Douglas, respectfully prays that a writ of certiorari issue to review the judgment and opinion of the United States Court of Claims entered on January 22, 1975.

Opinions Below

The opinions of the Trial Judge and the Court of Claims appear in the Appendix hereto (A. 1-35 and A. 36-63 respectively).

Jurisdiction

Judgment of the Court of Claims was entered on January 22, 1975. This petition for certiorari was filed within 90 days of that date. This Court's jurisdiction is invoked under 28 USC §1255(1).

Questions Presented

When a patentee adequately discloses the best mode of carrying out his invention, and the disclosure is sufficient to enable a person skilled in the art to make and use it, is the inventor required to go further and state that a given feature of that disclosure *must* be employed, in order for his patent to be interpreted as including that feature, when it comes to judging his contribution over the prior art?

Statutory Provision Involved

United States Code, Title 35, Section 112

§ 112. Specification

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Statement of the Case

The patent in suit was filed in 1946. It relates to jet propelled aircraft. Douglas' idea was to deflect one or more propulsion jets of a jet propelled aircraft through pivoting conduits to one of any various downward, rearward, or forward directions to improve lift on take-off, during flight, and on landing. He made it clear that his "one or more" jets would be located on each side of the aircraft and would be mounted to react in planes parallel to the plane of symmetry of the aircraft (A. 71, Col. 2, lines 2-16), and in Fig. 6 he showed a single jet in each wing balanced on opposite sides of the plane of symmetry of the aircraft and with the resultant jet forces acting through the center of gravity of the aircraft (A. 51, lines 1, 2).

Although simple, this arrangement of components is extremely important because it accounts for the success of the only high performance VTOL (vertical take-off and landing) jet aircraft in existence today, namely the "Kestrel" and its production version called the "Harrier". From 1950 onward, the United States spent many millions trying to develop a successful VTOL aircraft but failed. Numerous different approaches were tried but as Gen. McCutcheon put it, they "did not pan out". The only aircraft which was successful was the one which employed Douglas' arrangement of deflecting the jet stream into pivoting conduits balanced as in Douglas' Fig. 6 so that the resultant jet forces react through the center of gravity of the aircraft. This was called the "Vectored Thrust Principle" and the success of the "Harrier" was attributed to it.

The Congressional hearings on this subject are worth reading. Mr. Sikes of the Armed Forces Committee wanted to know why the U.S.A. had to "go overseas" to buy such an aircraft. The questioning and answers were as follows:

Pl. Ex. 51

Failure to Develop Domestically

[323] Mr. Sikes: In what respects do the aircraft in this general area which have been developed in the United States fail to meet the requirements that you expect to acquire in the Harrier? In other words, I find it hard to understand, when we have been putting money into this concept for 20-odd years to my own knowledge, that we come up with nothing that is usable and we have to go overseas to buy the aircraft. Whose fault is that?

General McCutcheon: I do not think it is anybody's fault, Mr. Sikes. I think in this country the particular techniques that were used and investigated to get the V/S[illegible] *did not pan out as well as the vectored thrust principle* that is used in the Harrier's engine. We had 12 or 15 different developments in this country, including tilt wings, tilt engines, fanjets, and so forth. Of these, I guess the fanjet shows about as much promise as any.

Mr. Sikes: Did we try to develop in too broad an area? Did we scatter our shot too much? In what way did we fail to accomplish what was desired?

[324] I still have not had an answer as to why all this developmental effort in the United States was unproductive and we had to go overseas to buy an aircraft.

General McCutcheon: This is a new area. When we started into it, nobody knew exactly what the final outcome would produce, so they had more or less to shoot across a broad spectrum and try all those approaches that appeared technically feasible.

The fact that this one surpassed all the others accounts for the successful accomplishment of the Harrier.

The Congressional record then went on to define the "vectored thrust principle" from which the similarity to Douglas' disclosure is apparent.

Vectored Thrust Principle

> Mr. Rhodes: Because some of the people who read this record may not know what a vectored thrust principle is, would you put something in the record at this point to explain that?
>
> General McCutcheon: Yes, sir.
>
> (The information follows:)
>
> Vectored thrust is a mechanization of turbojet engine exhaust nozzles which provides the capability to direct the engine thrust to desired angles relative to the airframe. Angles which may be selected range from directing the thrust rearward, in which case the vectored thrust aircraft operates the same as any other jet aircraft, to directing the thrust to some angle forward of vertically downward in which case a measure of reverse thrust is provided. When the engine nozzles are directed vertically downward, thrust is provided in the same direction as lift on the airplane wing, and if the magnitude of the thrust is equal to or greater than the weight of the aircraft, it will be capable of taking off and landing vertically. Vectored thrust angles between rearward and vertically downward are usable for "short takeoffs." In this case the vertical component of the thrust assists the airplane wing in lifting the weight of the aircraft, and the rearward component powers the aircraft as in conventional jet flight.

The suitability of Douglas' disclosure for VTOL was actually found by both lower Courts as follows: (A. 51)

10. Each of the disclosed embodiments [of the Douglas Patent] could, with appropriate balancing of forces and suitable controls, be used both in the VTOL and STOL modes.

11. The patent in suit discloses a workable arrangement for directionally controlling the jet thrust and one that would be understood by those ordinarily skilled in the art.

There is no doubt that Douglas did teach the fundamental relationship of the pivoting jets and the resultant forces acting through the center of gravity of the aircraft. In fact defendant conceded this by requesting the Trial Judge to make the following finding:

Defendant's Request for Finding of Fact No. 13

(C) The Discharge Nozzle of the Articulated Jet Tube in the Douglas Patent Is Located at or Near the Center of Gravity of the Aircraft

(13) According to the plaintiff's expert witness, Mr. Johnson, the Douglas patent discloses that the resultant force of the jet streams from all jet engines on an aircraft has to act in the plane of symmetry (Col. 2). This proves, and plaintiff's expert explicitly so stated, that the component of lift on the Douglas device has to pass through the center of gravity of the aircraft (Johnson Deposition, p. 111). The accuracy of this statement on the relationship between the center of thrust and the center of gravity of an aircraft was further corroborated by another of plaintiff's expert witnesses, Dr. Lancaster, who stated that the fundamental thing involved in the Douglas engine that is different and new, is that the center of thrust in Fig. 6 goes through the center of gravity. Dr. Lancaster emphasized that it is very important for the center of thrust to coincide with the center of gravity (Lancaster, 417-419).

And the Court below so found. (A. 50-51)

> Finding No. 9
>
> . . . The embodiment of Fig. 6 does illustrate an arrangement in which the resultant force acts near the center of gravity . . .*

Further the Trial Judge specifically found that the Kestrels and Harriers infringe the Douglas patent as follows:

> Finding No. 17d
>
> "The Kestrel and Harrier utilize substantially the same combination of elements functioning in substantially the same way to accomplish substantially the same result as the combination of claim 1."

The Full Court did not reverse this finding but merely treated it as moot.

Both Courts below, however, then went on to hold that because Douglas had failed to *teach* that the resultant forces of the jets *must* act through the center of gravity of the aircraft, his disclosure and claims were not entitled to be so read and they proceeded to hold that Douglas'

---

* The statement in the opinion below (A. 43, line 32) that the Examiner required cancellation of an attempt by Douglas to add description of the center of gravity relationship in his patent, takes the sentence out of context and is misleading. In fact, Douglas was trying to obtain a claim (claim 37) dealing with the "theoretical aerofoil projected onto the plane of symmetry of the aircraft" to cover the swept-back wing situation. The Examiner quite rightly rejected it as "new matter" (A. 127) and Douglas cancelled it. The portion of the amendment where the center of gravity was mentioned was also deleted at the same time but the rejection of the claim had been aimed at the "theoretical aerofoil" language, not at the center of gravity discussion. The opinion below, however, makes it appear as though the rejection was aimed specifically at the center of gravity discussion, when such is not the case.

invention was obvious in view of a combination of two ancient patents (Harris 1918, A. 130 and Higby 1929, A. 135), dating back into the era long before the advent of jet propulsion (to say nothing of VTOL) and neither of which discloses the critical relationships disclosed by Douglas.

Reasons for Granting the Writ

I. The Decision Below Conflicts With the Decision of this Court in *United States* v. *Adams,* 383 U.S 39 (1966).

There is nothing in 35 USC #112, which defines the requirements for a patent specification, stating that an inventor must do anything more than describe the best mode contemplated by him of carrying out his invention, and, as long as he describes enough to enable a person skilled in the art to "make and use same" he has done what is necessary. There is nothing which requires him to go further and state that a given feature of his description *MUST* be used.

In the case of *United States* v. *Adams,* 383 U.S. 39 (1966) the principal inventive contribution of Mr. Adams was that his battery could be activated by the use of plain tap water. But his patent did not teach that tap water *must* be used. Water was merely listed as optional. In fact, the use of plain tap water was not even mentioned in Adams' claims, but the Court gave him the benefit of the doubt and read it into the claims from the disclosure. We submit that the standard imposed by the Courts below whereby a disclosed feature will be given no weight, when assessing the inventive contribution, unless the invetor also states that it "must" be used, is in conflict with the *Adams* case, and is erroneous.

There is an additional parallel between the case at bar

and the *Adams* case. In the *Adams* case the Court was impressed by the fact that Mr. Adams had been originally aware of his invention's ability to operate on plain tap water and that he had mentioned it to others soon after filing his patent. Thus, his later reliance on it in the infringement action as a distinguishing feature over the prior art was not regarded as an "after-thought of an astute trial patent attorney". The same is true of Douglas. Soon after he filed his patent, he went to Vickers-Armstrong (makers of the famous "Spitfire"), and offered to license them. At that time he made it clear that, with his device, the jet forces should act "at or about the C.G. of the aircraft". The Vickers-Armstrong proposal which followed stated:

> "The basis of the present proposal is that if the jet were deflected about 60° downwards *at or about the C.G. of aircraft* by a flap in the jet pipe, then the approach would be made at higher R.P.M. and the resultant lift due or the deflected jet would provide the jet aircraft with approach characteristics similar to those obtaining with propeller-driven types." (emphasis ours)

Subsequently (in 1957) the British Ministry also acknowledged Douglas' much earlier disclosure of pivoting the resultant force of the jets through the center of gravity of the aircraft. They wrote as follows: (A. 91)

> "On the 10th August 1948, Mr. Smith of Vickers-Armstrong sent a copy of their Specification No. 512 to Mr. Scott-Hall. This specification discloses a Naval "Attacker" aircraft with a downwardly directed branch pipe from the rearwardly direction propulsion pipe. The branch being arranged so that *the reaction from the thrust passes through the centre of*

> *gravity of the aircraft.* The letter accompanying the Specification No. 512 states that the idea on which the specification is based is covered by a patent No. 26967/45 of a Mr. A. Douglas of Bristol." (emphasis ours)

These early statements (long before the Kestrels and Harriers) show that Douglas had emphasized to others the critical feature of pivoting the reaction of the thrusts through the center of gravity of the aircraft *at the time,* and that its emphasis in the case at bar is not the afterthought of an astute trial patent attorney. Thus, the refusal of the Court of Claims to give Douglas credit for this feature of his contribution and to view his claims in the context thereof is contrary to the doctrine of the *Adams* case.

It is also perfectly clear that neither the Harris (A. 130) nor the Higby (A. 135) references upon which the holding of invalidity below was based, discloses the critical feature of pivoting the reaction of the jets through the center of gravity of the aircraft. If the Court below had properly applied the doctrine of the *Adams* case and had given Douglas the benefit of what the Court below even *found* he had disclosed, it would not have been able to read these two references as invalidating the claims in issue and a different result would have been reached.

II. The Decision Below Raises Significant Problems Relating to the Operation of the Patent System and Introduces Confusion Requiring Resolution.

It should also be noted, however, that the reason for granting certiorari in this case is broader than the mere satisfaction of Douglas' rights. A principle of patent law is involved. Inventors often do not know all of the parameters of their inventions and this is particularly true

when an inventor is breaking totally new ground as Douglas was in 1946. In fact, all of the great land-mark inventions of the past now look strangely awkward when viewed from the basis of present day knowledge. For example, Sir Frank Whittle's famous patent on the first jet engine for aircraft (A. 119) bears no resemblance to a modern jet, and in that patent he never once said that any feature of it *must* be used. But yet he was given credit for his full disclosure. We think that giving such credit is proper, and conversely we think that any doctrine of patent law which holds that an inventor shall only be given credit for what he says ***must*** be done — disregarding what else he discloses, besides being contra to *Adams,* is a damaging and erroneous doctrine for patent law. In addition it would be a new doctrine, and, if followed by other Courts, would introduce confusion into a previously well settled area of patent law with a concomitant increase in the burden placed on the Courts to resolve same.

Accordingly, it is submitted that not only was the opinion below in error, but substantial reasons of public interest in the operation of the patent system, and in the reduction of confusion in the law, favor granting this petition.

Conclusion

Therefore, petitioner respectfully prays that the Supreme Court grant this petition to review the decision of the Court of Claims.

Respectfully submitted,

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APPENDIX A

IN THE UNITED STATES COURT OF CLAIMS
TRIAL DIVISION

No. 197-70
(Filed Jan. 31, 1974)

Robert B. Russell, attorney of record for plaintiff. *Henry C. Nields* and *Russell & Nields*, of counsel.
Donald E. Townsend, with whom was *Acting Assistant Attorney General Irving Jaffe*, for defendant.

AUBREY E. DOUGLAS v. THE UNITED STATES

OPINION *

COOPER, *Trial Judge:* In this suit under 28 U.S.C. § 1498, plaintiff seeks reasonable and entire compensation for the alleged unauthorized use by defendant of an invention described and claimed in his U.S. Patent No. 2,601,104, entitled "Jet Propulsion and Control Means Therefor," issued June 17, 1952. Jurisdiction is acknowledged and ownership of the patent is uncontested.

The suit involves jet-propelled airplanes. Accused to infringe are six British-made airplanes (called the Kestrel) and 11 replacement engines (called the Pegasus) that were brought to this country by defendant in late 1965. In addition, plaintiff alleges infringement by reason of the production version of the Kestrel (renamed the Harrier) being demonstrated by the British in this country in May 1969.

Defendant asserts invalidity of the patent on the grounds of lack of utility under 35 U.S.C. § 101, insufficient disclosure under 35 U.S.C. § 112 and obviousness under 35

* The trial judge's recommended decision and conclusion of law are submitted in accordance with Rule 134(h).

U.S.C. § 103. In addition, defendant urges the defenses of noninfringement and absence of liability by reason of "experimental use."

During pretrial proceedings, claims 1-3, 5 and 8 were alleged to be infringed. However, plaintiff's brief and proposed findings are restricted to claim 1. Accordingly, only that claim will be considered herein.

For the reasons stated hereinafter, claim 1 is found to be invalid for reasons of obviousness but, if valid, claim 1 would be infringed by the Kestrel and Pegasus but not by the Harrier.

General Background

Jet engines employ a jet pipe or tube through which hot combustion gases are directed to produce the thrust required to propel an airplane. Normally, the jet pipe opens rearwardly of the plane so that the propelling gases issue from the jet pipe in a direction opposite to the line of forward flight of the airplane.

This suit is concerned with the manner in which the thrust generated by a jet engine may be used, in addition to propelling the aircraft in the normal forward direction, to alter the conventional mode of takeoff and landing. Reference will be made to VTOL, STOL and V/STOL. The term VTOL indicates "vertical takeoff and landing" and refers to the takeoff or landing of a fixed-wing aircraft by only vertical movement of the aircraft. The term STOL indicates "short takeoff and landing" and refers to a fixed-wing aircraft that either takes off or lands with only a short horizontal run of the aircraft. The term V/STOL indicates "vertical and/or short takeoff and landing" and refers to an aircraft that is capable of operating in both the VTOL and STOL modes.

The term "vectored thrust" will be used herein. That term refers to the directional control of the thrust generated by the jet engine whereby the thrust may be directed

to a desired angle other than directly rearward of the plane.

I.

The Douglas Patent

The patent proposes a mechanism for selectively diverting the combustion gases of a jet engine to a direction other than that of their normal flow so that the thrust may be utilized for braking the airplane, or for assisting takeoff or landing, or for control purposes. Three embodiments are disclosed in the patent. The first (Figs. 1 and 2) employs a baffle for diverting at least a portion of the combustion gases from the jet tube to a pivotally mounted conduit. By pivoting the conduit, the thrust of the engine may be directed toward the ground and either forward (to brake the airplane) or backward (for increasing the lift of the plane).

The second embodiment (Figs. 3-5) employs, at the exit end of the jet tube, a number of arcuate members nested together and supported on a common pivot to form a curved conduit for directionally controlling the flow of combustion gases for the same purposes as the embodiment of Fig. 1.

The third embodiment (Figs. 6 and 7) has the engine mounted transversely of the aircraft with a pivotally mounted L-shaped conduit for directing the thrust of the engine in the desired direction.

In all three embodiments, directional control of the thrust is achieved by some form of a pivotally mounted conduit movable in a plane substantially perpendicular to the wing. By, for example, pivoting the conduit of any one of the three embodiments downwardly and rearwardly, the thrust of the engine produces two rectilinear components, one acting horizontally to move the plane forward and the other acting vertically to provide lift for the plane. This is the concept of "vectored thrust," *i.e.*, the thrust

generated by the engine has both magnitude and direction and is resolvable into rectilinear components.

The advantages of vectoring the thrust, as stated in the patent and during the prosecution of the application, are several. By directing the thrust downward and rearward, the forward speed of the airplane may be decreased while the engine is maintained at full power. This has particular advantages during landing in that the increased lift generated by the downward component of the thrust decreases both the plane's landing speed and the length of the landing run. Moreover, by maintaining the engine at full power, it is immediately available in the event of an emergency. During takeoff, the downward component of thrust decreases the speed at which the plane becomes airborne and thus decreases the length of the takeoff run.

In short, and as Douglas stated it in his patent, "a slow running aircraft and a fast running engine is thus made possible."

The sufficiency and operability of the Douglas disclosure

At the outset, defendant argues that the patent is invalid by reason of an inadequate disclosure under 35 U.S.C. § 112.

Defendant's attack is based primarily on the absence of any disclosure in the patent regarding the many technological problems encountered and solved by the British company in producing the accused Kestrel and Harrier airplanes. However, a patent specification is not required to be a production blueprint for constructing a jet airplane. *Trio Process Corp.* v. *L. Goldstein's Sons,* 461 F.2d 66, 74 (3d Cir. 1972), *cert. denied,* 409 U.S. 997. Nor can a patentee be expected to foresee every technological problem that may be encountered in adapting his idea to a particular use. Some experimentation and exercise of judgment is to be expected. *Binks Mfg. Co.* v. *Ransburg Electro-Coating Corp.,* 281 F.2d 252, 257 (7th Cir. 1960),

appeal dismissed, 366 U.S. 211 (1961); *International Nickel Co.* v. *United States,* 175 USPQ 209, 214-15 (Trial Div. Ct. Cl. 1972).

Giving due regard to the subject matter involved and the circumstances existing in 1945 when the application was filed, *Bowser, Inc.* v. *United States,* 181 Ct. Cl. 834, 388 F.2d 346 (1967), the disclosure adequately describes a mechanism for directionally controlling the thrust of a jet engine.

Defendant's argument that the patent fails to disclose a device that is sufficiently operative to satisfy the "useful" requirements of 35 U.S.C. § 101 is equally without merit. Plainly, the disclosed device is capable of performing the function attributed to it, that is, directionally controlling the thrust of a jet engine. The mere fact that problems may be encountered in adapting the device to a particular airplane having particular characteristics or that in one mode of its operation some additional controls would be required does not detract from the overall operativeness of the device. *Hildreth* v. *Mastoras,* 257 U.S. 27, 34 (1921).

OBVIOUSNESS OF CLAIM 1

Defendant's principal attack on the validity of the patent is the contention that claim 1 merely defines subject matter that would have been obvious within the meaning of 35 U.S.C. § 103. Although the resolution of the obviousness issue is ultimately one of law, certain basic factual inquiries must be made to set the context for the ultimate legal conclusion. *Graham* v. *John Deere Co.,* 383 U.S. 1, 17 (1966).

The prior art

Douglas was not the first to propose the idea of directionally controlling the thrust of a jet engine either to brake or increase the lift of an airplane. As early as 1918, in British Patent No. 118,123 granted to Harris, a jet

engine for propelling an airplane was disclosed. That patent specifically proposed that the tubes through which the propelling gases passed could be:

> * * * angularly movable in a vertical direction on horizontal trunnions or pivots for enabling or assist-in the aeroplane to rise or descend, and/or the tube may be movable laterally for enabling or assisting the aeroplane to turn. Normally of course the tube would occupy a position in which the aeroplane would be propelled horizontally in a straight path, and to change the movement of the aeroplane means may be provided to enable the pilot to readily alter the position of the tube as required. The tube may be moved to discharge the stream in the front of the aeroplane to produce a braking action and thus retard the speed of the aeroplane when landing. * * *

The prior patents to Anxionnaz (No. 2,396,911), Meyer (No. 2,420,323), and Lysholm (No. 2,280,835), and the text, GAS TURBINES AND JET PROPULSION FOR AIRCRAFT by Smith, all disclose, broadly, the concept of vectoring (*i.e.*, directionally controlling) the hot combustion gases of a jet engine. Lysholm, like Harris, suggests that directional control of the gases may be employed either for increasing the lift or for braking the aircraft. Anxionnaz, Meyer, and Smith disclose deflection of the lift or for maneuvering the aircraft.

The Higby patent (No. 1,104,895), instead of vectoring hot gases, discloses the concept of vectoring cold air from a centrifugal fan for imparting lift and assisting in maneuvering the airplane.

These prior art patents disclose a variety of ways for deflecting or vectoring the thrust. Anxionnaz uses shutters or flaps; Lysholm employs fixed conduits and flow control valves for channeling the thrust through the selected conduit; a swivelling nozzle is disclosed in the Smith text; in

Harris, the jet tubes are pivotally mounted; and in Higby, pivoting conduits are used.

Lysholm specifically discloses that deflection of the jet thrust will result in a fast running engine and a slow moving aircraft; that result is also inherent in both Harris and Meyer.

Differences between the prior art and claim 1

The functional concept expressed in claim 1 is that of diverting the combustion gases from a jet engine "to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft." This concept is expressly disclosed in the Harris patent. The differences between the Harris patent and claim 1 reside in the specific means for diverting the combustion gases. In particular, claim 1 specifies three elements: (a) means for diverting the gases from the jet tube, (b) a discharge conduit for receiving the diverted gases, and (c) means mounting the discharge conduit for pivoting movement. Harris does not disclose any means for diverting the gases from the jet tube; rather, Harris contemplates that the jet tube itself would be pivotally supported and would be used as the discharge conduit. Harris' arrangement would necessarily have the outlet of the jet tube "movable about an axis in an arc of approximately 180° in a plane substantially perpendicular to the plane of the wing" as called for in claim 1.

The Higby patent differs from the combination of claim 1 in two respects. By specifying "combustion gases," it is implied in claim 1 that the propelling jet is a jet engine; Higby utilizes a cold air centrifugal fan. Higby also differs from claim 1 in that the range of movement of the pivotable conduits in Higby would not be sufficient to direct the thrust in a forward direction to achieve a braking reaction. However, Higby does disclose a means for diverting flow of a gas from a rearward

direction, a discharge conduit for receiving the diverted gases, and means mounting the discharge conduit for pivoting movement for directional control of those gases.

Level of skill in the art

The first flight of a jet-propelled airplane occurred in 1939. In 1941, as a result of development work commencing in the late 1920's, the British flew their first jet airplane. The design of the powerplant used in that airplane subsequently was brought to the United States, and by late 1943 and early 1944, jet airplanes had been designed, built, and flown in this country.

Thus, as of October 1945, the field of jet propulsion, although in its infancy, had evolved into a working reality and had become a specialized part of the larger field of aircraft powerplants. In view of its obvious complexities, the level of skill of those working in that field must be considered to be relatively high, *Westinghouse Elec. Corp.* v. *Titanium Metals Corp.*, 454 F.2d 515 (9th Cir. 1971), *cert. denied*, 407 U.S. 911 (1972), although less well developed than when the accused structures were produced. At the least, the level of skill in 1945 had progressed beyond that represented by the disclosures of the prior art references discussed herein.

The obviousness determination

At the outset, it is necessary to address a matter not heretotfore mentioned but which appears to be the major argument advanced by plaintiff for nonobviousness. Plaintiff contends the Douglas patent discloses that the resultant force of the deflected jet thrust must pass "near to or through the center of gravity of the aircraft." This feature, plaintiff asserts, is "the patentee's vital contribution to the art" and is "essential" to the success of a V/STOL airplane.

There are two difficulties with this argument. The first is that the Douglas patent nowhere discloses that the

resultant force must pass through or near to the center of gravity either of the engine or of the aircraft. Indeed, during the prosecution of the patent, Douglas attempted to amend his disclosure to include this "teaching" but the Patent Office required its cancellation on the basis that it was not disclosed in the application as originally filed. Obedient to this requirement, and without argument, Douglas canceled the amendatory material.

Figure 6 of the patent does pictorially illustrate an arrangement in which the resultant force would act through the center of gravity. However, that showing does not aid plaintiff in his argument. Neither the elected species of Fig. 1, nor the embodiment of Fig. 3, disclose such a relationship. Since two of the three embodiments disclosed do not illustrate that relationship, it can hardly be said that the patent teaches that the resultant *must* act through a certain point.[1]

Thus, it is attributing too much to Douglas to assess the obviousness of his contribution, as defined by claim 1, in the context of an airplane in which the proper relationship between the vectored thrust and the center of gravity is maintained. The facts are that Douglas only proposed a solution to the problem of how, mechanically, to directionally vary the thrust, not how to vary the thrust while maintaining controllability of the aircraft. From the standpoint of adequacy, the specification will permit no broader interpretation. The pictorial illustration of Fig. 6, from which it may be *inferred* that the thrust acts at or near to the center of gravity, is impractical.

The second difficulty with plaintiff's argument is that this vital feature is not covered by claim 1. The arrange-

[1] There is some evidence that one ordinarily skilled in the art in 1945 would understand that the embodiments of Figs. 1 and 3 should be so arranged that the resultant would act through the center of gravity. That evidence, while helpful to plaintiff on the question of operativeness, is contrary to plaintiff's nonobviousness contentions.

ment of Fig. 6 falls outside the language of the claim, which requires the jet tube to be parallel to the line of flight. Moreover, the only claim that specifically defines the point through which the resultant acts is dependent claim 8 wherein the resultant is described as passing through "a point between the leading and trailing edges of the wing." However, even that limitation does not describe the resultant as passing through the center of gravity of the aircraft since, in conventional aircraft, the center of gravity is located at the quarter chord of the wing.

The claims are the measure of the invention and resolution of the obviousness question must be based on what is claimed. *Kemode Mfg. Co.* v. *United States,* 171 Ct. Cl. 698, 347 F.2d 315 (1965). Since Douglas only discloses, and claims, a mechanism for varying the thrust of a jet engine to achieve certain results, but has left it to those in the art to determine how to accomplish that without adversely affecting the controllability of the airplane, it is in that context that obviousness must be determined.

Turning then to claim 1, it is apparent from the foregoing analysis of the prior art that the Harris patent discloses the basic concept of vectoring the thrust to provide either lift or braking. This basic concept being known, the remaining aspects of the claim relate only to the mechanics by which the thrust is directionally controlled.

The prior art discloses a variety of ways for directionally controlling the propelling thrust in an airplane. Harris discloses pivoting the jet tubes for that purpose. While Harris is ambiguous in that it is unclear whether the entire engine would be pivoted with the tubes or the jet tubes would pivot independently of the engine, this does not alter the pertinence of that reference. Even if it is assumed that Harris intended the engine to pivot as

a unit with the tubes, Higby discloses a mechanism for maintaining the engine stationary while directionally controlling the thrust. In view of Higby, the conclusion is inescapable that one skilled in the art who wanted to accomplish the objectives of Harris, but without pivoting the engine, would find it obvious to use the independently pivotable conduits disclosed by Higby. No new and unobvious function would result from such a modification of Harris.

Given the relatively high level of skill in this particular art, given the suggestion in Harris for pivotally supporting the jet tube, and given the disclosure of the Higby patent in which pivotally mounted conduits are plainly disclosed, it must be concluded that it would have been obvious in 1945 that the claimed arrangement of conduits could be used to control the direction of the thrust.

In reaching this conclusion, due regard has been given to the presumptively correct decision of nonobviousness implicit in the patent examiner's allowance of this patent. However, neither Harris nor Higby was cited by the examiner. Where, as here, the most pertinent prior art references were not cited by the examiner, the presumptions to which the patentee is entitled are greatly weakened, if not entirely overcome. *Nossen* v. *United States,* 189 Ct. Cl. 1, 416 F.2d 1362 (1969), *rehearing denied,* 191 Ct. Cl. 198, 422 F.2d 1340 (1970), *cert. denied,* 400 U.S. 823.

As a means of guarding against "slipping into hindsight," *Monroe Auto Equip. Co.* v. *Heckethorn Mfg. & Supply Co.,* 332 F.2d 406, 412 (6th Cir. 1964), *cert. denied,* 379 U.S. 888, the secondary considerations urged by plaintiff in support of nonobviousness have also been carefully reviewed. In large part, these are based on the undisputed success of the Kestrels and Harriers which were the first usable aircraft with V/STOL capabilities and which are the only operational aircraft with that capability even

today. However, to be of any value on the issue of obviousness, success must be attributable to the *claimed* invention and not to other factors. *Palmer* v. *United States*, 182 Ct. Cl. 896 (1968). Here, the evidence shows that other factors are highly significant to the success of those airplanes.[2]

As noted previously, a major consideration in V/STOL airplanes is the pilot's ability to control the airplane during vectoring of the thrust. Controllability was achieved in the accused planes in two ways. The first was the use of four nozzles so arranged that the resultant force of the vectored jets acted at or near to the center of gravity of the airplane. The other was the use of a system of puffer jets to provide an auxiliary control. Neither of these is disclosed nor claimed in the Douglas patent.

In summary, Douglas proposed a specific mechanism for accomplishing the objectives earlier suggested by Harris. The mechanism itself was an obvious variation of that previously suggested by Higby. Unobviousness, if any, lay not in the mechanism but in the manner in which the mechanism was used in an airplane to vary the thrust direction while maintaining controllability of the airplane. The builders of the accused Pegasus, by expending some $70 million in the development of that engine, solved that problem, not Douglas. Having contributed nothing to the development of the critical relationship, Douglas cannot rely on the subsequent success of the accused airplanes to sustain the validity of his patent.

Claim 1 is invalid under 35 U.S.C. § 103.

II.

Although the determination that the patent is invalid is sufficient grounds for dismissal of the petition, *Nossen*

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[2] Although plaintiff did disclose his ideas to the Britsh company that designed the Pegasus, there is no evidence that any use was made of those disclosures by that company.

v. *United States, supra,* substantial trial time was devoted to the issues of infringement and experimental use, and the parties have fully briefed these issues. For this reason, as well as the desirability of the trial court disposing of all issues so that a single review will dispose of the case, *Sisko* v. *Southern Resin & Fiberglass Corp.*, 373 F.2d 866 (5th Cir. 1967), *cert. denied,* 389 U.S. 824; *Blair* v. *Westinghouse Elec. Corp.*, 291 F. Supp. 664 (D. D.C. 1968), *aff'd,* 438 F.2d 136 (D.C. Cir. 1970), findings have been made on those issues and each will be briefly discussed.

INFRINGEMENT

Defendant asserts five grounds in support of its contention that claim 1 is not infringed by the Kestrel or Pegasus engines. Only one of those grounds merits any comment.

Claim 1 calls for the outlet end of the discharge conduit to be movable "in an arc of approximately 180°." It is undisputed that the nozzles on the Kestrel only have a range of movement of from 0° to approximately 94°.

In ascertaining the meaning of a limitation in a claim, it is appropriate to refer to the specification and the file wrapper history. *Autogiro Co. of America* v. *United States,* 181 Ct. Cl. 55, 384 F.2d 391 (1967), *rehearing denied,* 184 Ct. Cl. 801 (1968). The file wrapper reveals that Fig. 1 was the elected species throughout the prosecution of the Douglas application. The range of movement of the conduit in Fig. 1 is no more than 45°. Yet the file history shows that claims containing the phrase "in an arc of approximately 180°" were directed to that embodiment and were accepted by the examiner as being readable on that embodiment. From this it appears that the meaning to be attributed to this phrase is that the discharge outlet is movable within an arc of no greater than 180° to accomplish the claimed function. Since an arc of

45° falls within an arc of 180°, that construction of the phrase is consistent with the elected species of Fig. 1. On the other hand, defendant's contention that this phrase requires the conduit to be movable through the full 180° would require a finding that claim 1 does not even cover the elected species of Fig. 1. Such a finding is not warranted by the file history.

Since the accused range of movement of 0°-94° falls within an arc of 0°-180°, the limitation, as properly construed, is present in the accused aircraft.

In summary, claim 1 is directly readable on the Kestrel aircraft and on the Pegasus engines used in that plane. In addition, each of the hot nozzles on these accused structures perform substantially the same function in substantially the same way as the claimed combination. Therefore, a case of infringement has been made out. *Autogiro Co. of America* v. *United States, supra.*

Turning to the Harrier, that plane, in all respects material to the infringement issue, is the same as the Kestrel. However, the only accused use of the Harrier is based on a demonstration of that aircraft at Andrews Air Force Base and at Norfolk, Virginia, during the period May 14-19, 1969. That demonstration was arranged by the British as a result of the planes being in this country at the conclusion of a trans-Atlantic race. The evidence is that the British Defense Sales Agency initiated, hosted and performed the demonstration for members of Congress and military officials. The planes were the property of the British and flown by British pilots. The purpose of the demonstration was to promote the sale of the Harriers. Defendant's only role in the demonstration was in providing the facilities at the air bases where the demonstrations were held. Subsequently, the Marine Corps did procure some Harriers but that procurement occurred after the patent had expired.

To establish liability under 28 U.S.C. § 1498, there must be a manufacture or use by or for the United States. Clearly, the Harriers were not manufactured either by or for defendant. Nor was there a use of the Harriers by the United States, the only operational use being by the British. This leaves only the question of whether the demonstration was a use *for* the United States.

It is concluded that it was not. Defendant's role was solely that of providing the facilities and observing the demonstration. Although a sales demonstration may be an infringing use, *see, e.g., Scott & Williams, Inc.* v. *Hemphill Co.,* 14 F. Supp. 621 (S.D. N.Y. 1931), plaintiff has cited no authority for the proposition that the observer of the demonstration can be held liable as an infringer. The planes having been owned and operated by the British and the demonstration having been promoted and financed by them for the purpose of inducing a purchase of the aircraft, there was no taking by the United States and no use for the United States.

Nor does the fact the Harrier was subsequently procured alter this conclusion. At most, this would suggest that, at the time of the demonstration, defendant intended to procure the accused aircraft. However, intent is not a sufficient basis on which to establish liability. *Cf., White* v. *Walbridge,* 46 F. 526 (C.C.D. Vt. 1891). To be actionable, an act of infringement must be shown to have occurred prior to the expiration of the patent. The only proven action of defendant was procurement of the Harrier and that occurred after expiration of the patent.

EXPERIMENTAL USE

Defendant urges that, even if the claims cover the accused Kestrel and Pegasus, it is not liable for the reason that its only use of those items was experimental.

The so-called "experimental use" defense to liability for infringement had its origins in 1813 in *Whittemore* v.

Cutter, 29 F. Cas. 1120 (No. 17,600) (C.C.D. Mass. 1813), when Justice Story, sitting as a circuit judge, commented that it was not the intent of the patent laws to hold liable one who made an infringing device "merely for philosophical experiments, or for the purpose of ascertaining the sufficiency of the machine to produce its described effects." By 1861,[3] it was "well settled that an experiment with a patented article for the sole purpose of gratifying a philosophical taste, or curiosity, or for mere amusement is not an infringement of the rights of the patentee." *Poppenhusen* v. *Falke,* 19 F. Cas. 1048 (No. 11,279) (C.C. S.D. N.Y. 1861).

Well settled though it may be, a review of the decided cases reveals that the defense of experimental use has been only sparingly applied. Many courts have held that the experimental use defense is not available where the use, although of an experimental nature, was in connection with the user's business. *Poppenhusen* v. *New York Gutta Percha Comb Co.,* 19 F. Cas. 1059 (No. 11,238) (C.C. S.D. N.Y. 1858) (product of the experiment was sold); *Albright* v. *Celluloid Harness-Trimming Co.,* 1 F. Cas. 320 (No. 147) (C.C. D. N.J. 1877) (unsuccessful experiment while tooling up for production); *Clerk* v. *Tannage Patent Co.,* 84 F. 643 (3d Cir. 1898) (experimental testing to determine whether to take a license); *Bonsack Mach. Co.* v. *Underwood,* 73 F. 206 (C.C. E.D. N.C. 1896) (use of patented machine to demonstrate defendant's improvements); *Cimiotti Unhairing Co.* v. *Derboklow,* 87 F. 997 (C.C. E.D. N.Y. 1898) (experimenting to devise improvements while using machine in course of business); *Radio Corp. of America* v. *Andrea,* 15 F. Supp. 685 (E.D. N.Y.

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[3] For a more complete exposition of the development of the experimental use defense, see, Bee, *Experimental Use as an Act of Patent Infringement,* 39 J. PAT. OFF. SOC'Y. 357 (1957). See also, 3 ROBINSON ON PATENTS § 898 (1890).

1936), *modified,* 90 F.2d 612 (2d Cir. 1937) (factory testing of units prior to sale); *Sprout, Waldron & Co.* v. *Bauer Bros.,* 26 F. Supp. 162 (S.D. Ohio 1938) (use of machine to operate on customer's products); *Northill Co.* v. *Danforth,* 51 F. Supp. 928 (N.D. Cal. 1942), *modified on other grounds,* 142 F.2d 51 (9th Cir. 1944) (experiments made in connection with the business); *Spray Refrig. Co.* v. *Sea Spray Fishing, Inc.,* 322 F.2d 34 (9th Cir. 1963) (experiment conducted during commercial fishing operation).

Some few courts, where only a single isolated use has been involved, have allowed the defense even though the alleged experiments were plainly related to a commercial operation. *Standard Measuring Mach. Co.* v. *Teague,* 15 F. 390 (C.C. D. Mass. 1883) (machine made to demonstrate defendant's own patented improvement); *Dugan* v. *Lear Avia,* 55 F. Supp. 223 (S.D. N.Y. 1944), *aff'd,* 156 F.2d 29 (2d Cir. 1946) (no use of the single device made); *Akro Agate Co.* v. *Master Marble Co.,* 18 F. Supp. 305 (N.D. W.Va. 1937) (use of machine to determine suitability for production); *Kaz Mfg. Co.* v. *Chesebrough Ponds,* 317 F.2d 679 (2d Cir. 1963) (use of device in advertising of defendant's own product).

In *Ruth* v. *Stearns-Roger Mfg. Co.,* 13 F. Supp. 697, 703 (D. Colo. 1935), *rev'd on other grounds,* 87 F.2d 35 (10th Cir. 1936), it was held that use of the accused machines in the laboratory of a college for teaching purposes was not an infringing use. But, in *Beedle* v. *Bennett,* 122 U.S. 71 (1887), it was held that a private use of a device for one's personal convenience was an infringing use.

The very restricted circumstances under which the defense has been permitted suggests, as at least one court has observed, that the defense is nothing more than an expression of the maxim *de minimis non curat lex. Radio Corp. of America* v. *Andrea, supra.* Most certainly, in none of the cases from other federal courts has the de-

fense been permitted where there was a pattern of systematic exploitation, extending over a prolonged period, of a plurality of the accused devices for the purpose of furthering the legitimate interests of the user.

The two cases[4] which suggest that experimental use is applicable in other than *de minimis* situations are *Ordnance Eng'r Corp.* v. *United States,* 84 Ct. Cl. 1 (1936), *cert. denied,* 302 U.S. 708 (1937), and *Chesterfield* v. *United States,* 141 Ct. Cl. 838, 159 F. Supp. 371 (1958). In the *Ordnance Eng'r* case, the court excluded from its accounting some 7,425 shells built for test firing and for experimental purposes. In *Chesterfield,* 3,679 pounds of an alloy were held noninfringing by reason of experimental use and testing. However, neither case necessarily indicates that this court affords, as against the Government, a broader scope for experimental use than that given by other courts in private litigation. In the *Ordnance Eng'r* case, it appears that the deduction for experimental use was uncontested, the court making no reference to the doctrine in its opinion. In *Chesterfield,* there was no evidence as to the use of the bulk of the alloy so it was simply treated in the same manner as the small part that was found to have been used experimentally. Significantly, the *Chesterfield* case expressly relied on the *Dugan* and *Bonsack* cases, *supra,* thus suggesting that the rule here is the same as in other federal courts.

While each of the parties has suggested what they view to be the appropriate rule governing permissible experimental use by the Government, further consideration of that question in what is already an overlong opinion is unnecessary to a decision in this case. The facts here plainly show that defendant's activities fall outside the

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[4] Another case, *United States* v. *Palmer,* 128 U.S. 262 (1888), cited by plaintiff, is not in point. That was a contract action, although for experimental use of a patented invention.

scope of permissible use that would be afforded under any statement of the experimental use rule.

Six Kestrels and 11 Pegasus engines, representing several million dollars of equipment, were used by defendant. Each of the Army, Navy, Air Force, and NASA used the equipment. The use extended over a period from December 1965 up to and beyond the expiration date of the patent, June 17, 1969. During that period, extensive programs obviously costing thousands of dollars and involving substantial numbers of people were conducted by each of the military services and NASA. These programs were consistent with the assigned mission or statutory authority of each department or agency. At no time were the accused devices used for amusement, to satisfy idle curiosity, or for philosophical inquiry; to the contrary, each use was in keeping with the legitimate business of the using agency and served a valuable governmental and public purpose.

Having employed a number of the accused devices in a systematic program, extending over a prolonged period, to serve the legitimate interests of a number of services and agencies, there is no basis under 28 U.S.C. § 1498 for excusing that use as *merely* experimental.

The patent being invalid, the petition must be dismissed.

FINDINGS OF FACT

1. U.S. Patent No. 2,601,104, entitled "Jet Propulsion and Control Means Therefor," issued June 17, 1952, on an application filed September 10, 1946. The patent claims the priority date of British Patent No. 643,959, filed in Great Britain on October 15, 1945.

2. Aubrey E. Douglas, an individual, is a British subject residing at Saltford Farm, Somerset, England. Plaintiff Douglas' ownership of the patent has not been contested in this suit. Plaintiff did not appear at the trial, defendant having waived its right to require his presence.

Disclosure of the patent

3. The problem of controlling a jet aircraft is particularly critical at slow speeds when the effect of the airfoil surfaces is less due to the reduced velocity of the air passing over them. Thus the control of all fixed-wing aircraft is said to be "sluggish" as the aircraft approaches the stall speed. This problem is compounded in jet-propelled fixed-wing aircraft by the fact that jet engines do not accelerate rapidly. Thus, if the pilot desires a sudden burst of power from the engine, as in a balked landing situation, a jet engine is poorly equipped to provide it. As a result, jet aircraft have been required to land at high speed, to the detriment of certain other safety factors, and with the requirement of long landing fields.

4. The patent in suit discloses apparatus for the control of jet-propelled aircraft during takeoff, landing, and while airborne. In particular, Douglas' idea was to divert the efflux of the jet away from the normal rearward direction, to various other directions including downward and rearward, directly downward, downward and forward, and/or directly forward so as to provide lift and/or braking components of reaction, while still maintaining the operation of the engine at full power and available for redirection to provide normal forward thrust, if desired. A slow moving aircraft and fast running engine are thus made possible by the deflection of the jet stream.

5. (a) Three embodiments for controlling the direction of the output combustion gases from a jet engine are disclosed and illustrated. The embodiment shown in Figs. 1 and 2 employs a baffle D for diverting at least a portion of the combustion gases from the normal rearward direction of flow in jet tube C into conduit E, and thence into pivotably mounted conduit H. Conduit H may be pivoted through a range of about 40° in order to vector combustion gases

either forwardly (for braking) or downwardly (for additional lift).

(b) In the second embodiment (Figs. 3-5), the jet tube terminates in an elbow joint formed from a number of arcuate members constructed to nest together in order to form a curved conduit. This elbow joint deflects the combustion gases downwardly from their normal "straight through" rearward flow, to any point on an arc of 180°.

(c) The third embodiment (Figs. 6, 7) shows a jet engine A mounted in the wing of an aircraft. The longitudinal axis of engine A is transverse to the long axis or horizontal center line of the aircraft. The engine is provided with a conduit or tube C. In forward flight, the normal position of the jet tube C is directly rearward. By pivoting the tube C through any chosen degree in an arc of 0° to 110°, the direction in which the combustion gases are discharged may be varied.

(d) The first two embodiments utilize essentially three components:

(i) a jet tube through which the gases normally discharge for propulsion of the aircraft;

(ii) means for diverting the gases from their normal rearward direction; and

(iii) a movable conduit that receives the diverted gases and directs them to the desired direction.

In the embodiment of Fig. 6, all three components are combined into a single element, the pivotably mounted L-shaped conduit C.

6. The Douglas patent discloses a vectored thrust principle in which direction other than the normal rearward direction may be imparted to the thrust generated by the hot combustion gases from a jet engine.

7. In any airplane, it is important that the resultant of the jet thrust forces pass through or near to the center of gravity (c.g.) of the airplane. If, by vectoring the jet

thrust, the resultant force passes to the rear of the c.g. of the airplane, a nosedown attitude will be imparted to the aircraft which, if not corrected, will cause the aircraft to nosedive. The need for the resultant forces to pass through the c.g. is particularly critical when a plane is operated in the VTOL mode because there is no airflow over the ailerons and rudder which would enable the pilot to use those controls to maintain the correct attitude of the airplane. This is less critical during STOL operation where there is airflow over the control surfaces.

8. The Douglas specification contains no mention of the relationship between the resultant of the vectored thrust and the center of gravity. During prosecution of the patent, Douglas attempted to amend his specification to include the statement that "the reactionary effect generated by the diversion of the jet should pass through the proximity of the center of gravity of the aircraft." The examiner required cancellation of this statement, holding that it was new matter, and Douglas did not contest that requirement. The examiner did permit Douglas to insert a claim (claim 8) that calls for the reaction of the vectored jet to pass "through a point between the leading and trailing edges of the wing." However, that point is not necessarily coincident with the center of gravity which, in conventional aircraft, is normally located at the quarter chord of the wing.

9. The embodiments of Figs. 1 and 3 of the Douglas patent do not show the resultant force as passing through the center of gravity of the aircraft. The embodiment of Fig. 6 does illustrate an arrangement in which the resultant force acts near the center of gravity. Figs. 1 and 3 employ a double 90° bend for the bases; Fig. 6 has a single 90° bend.

10. Each of the disclosed embodiments could, with appropriate balancing of forces and suitable controls, be used both in the VTOL and STOL modes.

Sufficiency and operativeness of the disclosure

11. The patent in suit discloses a workable arrangement for directionally controlling the jet thrust and one that would be understood by those ordinarily skilled in the art. Those in the art would understand that, to achieve a controllable aircraft, it would be necessary, in addition, to minimize pitching moments about the center of gravity of the aircraft created by varying the direction of the jet.

12. Douglas submitted his ideas to Vickers-Armstrong Ltd. in 1948. That company designed an airplane based on Douglas' idea. Although the airplane was never built, there is no evidence that the company had any difficulty in understanding the idea. None of the other companies or organizations to which Douglas disclosed his idea expressed any lack of understanding as to its operativeness or utility.

The scope and meaning of the claim

13. Claim 1, the only claim now asserted by plaintiff, provides as follows:

> Apparatus for controlling the reaction of a propelling jet in a rigid wing aircraft, comprising a jet tube mounted approximately parallel to the line of flight. means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal, a discharge conduit associated with the jet tube adapted for receiving the diverted gases, the discharge outlet of said discharge conduit being selectively movable about an axis in an act of approximately 180°, in a plane substantially perpendicular to the plane of the wing for directionally controlling the discharge of gases from the conduit to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft.

14. (a) During prosecution of the patent, Douglas was required to make an election of species. Douglas elected the species of Figs. 1 and 2 wherein the discharge conduit is rotatable through a range of approximately 45°. Simultaneous with this election of species, Douglas presented claims which included the limitation that the discharge conduit be movable "in an arc of approximately 180°." Although the Examiner initially interpreted this limitation as calling for the jet tube to be movable in an arc, and rejected the claims as being misdescriptive, that rejection was withdrawn.

(b) Thereafter, Douglas continued to present claims containing the limitation "in an arc of approximately 180°" and continued to assert that that limitation was applicable to an arrangement such as shown in Figs. 1 and 2. Nowhere in the file wrapper history is there any indication that the Examiner either failed to understand the broad interpretation that Douglas placed on this limitation or disagreed with that interpretation.

(c) The species of Figs. 1 and 2 remained the elected species throughout the prosecution of the Douglas patent. The file wrapper history shows that the phrase "in an arc of approximately 180°" was intended to cover the species of Figs. 1 and 2 wherein the range of movement was no more than 45°.

(d) The meaning to be attributed to the phrase "in an arc of approximately 180°" is that the discharge outlet is movable within an arc of no greater than 180° to accomplish the claimed function. Any discharge outlet that is movable through an arc of up to 180° comes within the scope of this limitation.

(e) The limitation that the discharge outlet is movable "in a plane substantially perpendicular to the plane of the wing" was inserted in the claim to distinguish it from the arrangement shown in Gazda Patent No. 2,486,272

wherein a reaction jet was movable in a plane parallel to a helicopter blade.

(f) The "normal direction" referred to in claim 1 refers to the direction in which the bases issuing from a jet tube would normally flow in propelling an airplane, *i.e.*, in a direction opposite to the forward line of flight.

The accused devices

15. Plaintiff alleges defendant's use of six aircraft designated the Kestrel to be an infringement of his patent. The Kestrel utilizes an engine called the Pegasus and plaintiff alleges that 11 Pegasus engines, in addition to those in the Kestrels, were used by defendant in violation of the patent. Plaintiff further alleges that the production version of the Kestrel, renamed the Harrier, was used in the United States and that that aircraft infringes his patent.

16. (a) The Pegasus, used in both the Kestrel and the Harrier, is a ducted fan engine having a bifurcated jet pipe which divides the hot gases into two streams, diverting one stream to one side of the engine and the other stream to the opposite side of the engine. A pair of rotatable nozzles on each side of the engine receives the diverted stream. By rotating the nozzles, the hot gases may be diverted at any angle from directly rearward to an angle of slightly forward and downward. In addition to the foregoing two nozzles (called the hot nozzles), the Pegasus also uses a pair of forward nozzles, each of which receives a stream of cold air, with the forward nozzles functioning in the same manner as the hot nozzles to direct the cold air in the desired direction.

(b) As mounted in the aircraft, the center of gravity of the Pegasus engine is at or near the center of gravity of the airplane. The cold nozzles are positioned ahead of the center of gravity of the engine and the hot nozzles are positioned behind the center of gravity of the engine. The

resultant of the thrust forces generated by the gases passing through the hot and cold nozzles is at or near the center of gravity of the aircraft. The use of four nozzles, two hot and two cold, together with the balanced arrangement of the nozzles about the c.g. of the aircraft is critical to the controllability of the Kestrel and Harrier. Controllability is further enhanced by the use of a system of puffer jets which serve as auxiliary controls.

Infringement

17. (a) Both the Kestrel and Harrier are "rigid wing aircraft." The Pegasus engine produces a "propelling jet"; the bifurcated jet pipe and the associated nozzles constitute "apparatus for controlling the reaction" of the propelling jet. The forward portion of the jet pipe is a "jet tube mounted approximately parallel to the line of flight." The bifurcated portion of the jet pipe diverts the gases at an angle of about 90° to the normal rearward direction and thus constitutes "means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal." The hot nozzle comprises a "discharge conduit associated with the jet tube adapted for receiving the diverted gases." The discharge outlet of the hot nozzle is "selectively movable" for "directionally controlling the discharge of gases from the conduit to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft."

(b) The discharge nozzles of the Pegasus engine, as mounted and used in the aircraft, may be rotated through an arc of approximately 94° and, hence, rotation occurs "in an arc of approximately 180°."

(c) The discharge nozzles of the Pegasus engine rotate in a plane that is displaced by a small amount from a "plane substantially perpendicular to the plane

of the wing." The purpose of this small deviation from exact perpendicularity is to direct the hot gases away from the wheels of the aircraft.

(d) The Kestrel and Harrier utilize substantially the same combination of elements functioning in substantially the same way to accomplish substantially the same result as the combination of claim 1.

18. Defendant did not procure any Harrier aircraft until after the patent in suit had expired. The only uses of Harrier in the United States prior to June 17, 1969, were demonstrations of that aircraft at Andrews Air Force Base and at Norfolk, Virginia, on May 14-19, 1969. Those demonstrations were arranged by the British while the planes were in this country at the conclusion of a trans-Atlantic race. The British Defense Sales Agency initiated the demonstrations for the purpose of promoting the sale of Harriers. The planes were the property of the Britsh and were flown by British pilots. Defendant's only role in the demonstration was in providing the facilities at the air bases where the demonstrations were held and in arranging for the attendance of members of Congress and military officials.

The scope and content of the prior art

19. The first flight of a jet-propelled aircraft occurred in 1939. However, the use of gas turbines as a jet engine for propelling aircraft was suggested long prior to that time. One such early suggestion is contained in British Patent No. 118,123, issued in 1918. The British patent to Whittle (No. 347,206), issued in 1930, marks the practical beginning of the efforts to produce an operational jet airplane.

20. Almost from the very inception of jet propulsion as a means for propelling an airplane, it was realized that the jet thrust also could be used for braking, lift, or

control of an airplane. The British patent to Harris (No. 118,123) and the patents to Anxionnaz (No. 2,396,911), Meyer (No. 2,420,323), and Lysholm (No. 2,280,835), all disclose, broadly, the concept of vectoring, or directionally controlling, the hot gases of a jet engine. The patents to Harris and Lysholm specifically disclose the use of a vectored jet thrust either to impart lift or to provide a braking reaction on the aircraft. The Higby patent (No. 1,704,985) discloses the concept of vectoring cold air from a centrifugal fan for imparting lift to an airplane. The patents to Anxionnaz and Meyer, as well as the text GAS TURBINES AND JET PROPULSION FOR AIRCRAFT by Smith, disclose the concept of deflecting the jet to assist in maneuvering the aircraft. Vectoring of the gases in both Higby and Lysholm, as well as in the early patent to Valdez (No. 1,629,767), was accompanied by passing the gases through two bends.

21. Various techniques for deflecting or vectoring the jet thrust were known prior to the Douglas patent. One technique was the use of shutters or flaps (Anxionnaz); another was the use of fixed conduits and flow control valves (Lysholm); still another was the use of a swivelling nozzle (Smith text, Plaintiff's Exhibit 24A); a further technique was pivotably mounting the jet tubes (Harris); another was the use of pivotally mounted L-shaped conduits (Higby; Valdez).

22. The patents to Anxionnaz, Lysholm, Meyer, and Valdez were cited by the Patent Office during prosecution of the Douglas patent. The Harris and Higby patents were not cited.

23. The manner in which the jet tubes in the Harris patent would be pivoted is ambiguous. Although suggesting the use of trunnions as pivots for the jet tubes, it is unclear whether the tubes would pivot independently of

the remainder of the engine or the engine would pivot with the tubes.

24. The use of pivotably mounted conduits for directionally controlling the discharge of gases, with the conduits being selectively movable about an axis in a plane substantially perpendicular to the plane of the wing, is disclosed in both the Harris and Higby patents.

25. By late 1943 and early 1944, jet airplanes had been designed, built, and flown in this country. By October 1945, the field of jet propulsion had become a specialized part of the larger field of aircraft powerplants. The level of skill of those working in that specialized field as of that date was relatively high.

Differences between prior art and claim 1

26. (a) Claim 1 does not require that the jet engine remain stationary. The claimed concept of diverting combustion gases in an arc to effect, in at least one position, a braking reaction on the aircraft is disclosed in the Harris patent. The combination of claim 1 differs from Harris only in the specific mechanical means employed to divert the combustion gases through the desired arc. In particular, Harris does not disclose any means for diverting the gases from the jet tube; rather, Harris would direct the gases by pivoting the jet tube itself, a concept similar to Fig. 6 of the Douglas patent. In fact, to the extent claim 1 is readable on Fig. 6, it is also readable on the Harris patent.

(b) The combination of claim 1 differs from Higby only in the type of propelling jet employed and the degree of rotation of the discharge conduit. Higby contemplates the use of cold air instead of hot combustion gases; nor does Higby contemplate pivoting the discharge conduits to a forward position to impart a braking reaction. Higby discloses the same essential combination of elements for directionally controlling the propelling jet as that em-

ployed in the Douglas patent and the accused aircraft, *i.e.*, (i) a means for diverting the flow, (ii) a discharge conduit for receiving the diverted gases, and (iii) means mounting the discharge conduit for pivoting movement about an axis in a plane substantially perpendicular to the plane of the wing. As in Douglas, the gases in Higby would pass through two 90° bends.

Other considerations bearing on validity

27. (a) Based on Douglas' idea, Vickers-Armstrong proposed an airplane in which the jet thrust could be deflected up to 60°. In order to obtain the proper balance of forces and avoid the introduction of pitching moments about the c.g. when the jet was deflected, very substantial modifications in the airplane were proposed. Even then, the airplane would have had no VTOL capability. This proposal did not progress beyond the preliminary design stage.

(b) It was not until the advent of the light weight gas turbine engines having a high thrust-to-weight ratio that it became apparent that rigid-wing aircraft with V/STOL capability could be built. Starting in about 1952, essentially four approaches were taken by the industry: tilt thrust (the wings and/or the engines are tilted to direct the thrust in the desired direction); augmented thrust (lift fans are driven by the engines to generate the lift); dual propulsion (separate engines for lift and for propulsion are used); and vectored thrust (represented by the accused airplanes).

(c) Development in the United States was concentrated in areas other than vectored thrust. By 1969, some 12-15 development programs, at a cost of millions of dollars, had been undertaken in the United States in an attempt to produce a satisfactory V/STOL airplane. None of those

programs was successful in terms of producing a usable aircraft.

(d) A fundamental problem in vectoring the thrust of a propelling jet is in maintaining the controllability of the airplane as the direction of the thrust is varied. Those in the art recognized that directional control of the thrust could be achieved without adversely affecting the trim so long as the resultant force always passed through or near the center of gravity; however, as indicated by the substantial modifications proposed by Vickers-Armstrong in the hope of accomplishing this goal, this was difficult to achieve. Douglas' only suggestion for achieving this critical relationship is contained in Fig. 6 wherein the engine is located transversely of the airplane, approximately in line with the c.g. of the aircraft; however, the transverse mounting of the engine is impractical.

(e) The British-made Kestrel and Harrier aircraft, using the vectored thrust principle, are the only usable V/STOL aircraft that have been developed and built to date. Approximately 2.5 million technical man hours, at a cost of approximately $70 million, were expended in developing the Pegasus engine used in the Kestrel aircraft. Although Douglas did disclose his ideas to the builder of the Pegasus engine, there is no evidence that any use was made of that disclosure.

Experimental use

28. In 1962, the United States, Great Britain, and West Germany entered into a tripartite agreement for the joint evaluation of V/STOL concepts using the Kestrel airplane. A Kestrel Evaluation Squadron, made up of personnel from the three countries, conducted the evaluation at an RAF base in England.

29. Upon completion of the tripartite evaluation, six Kestrels, replacement engines and spare parts therefor,

together with the American pilots and enlisted personnel in the tripartite squadron, were transferred, in December 1965, to Fort Campbell, Kentucky, to carry out what were called National Trials. These trials were to be conducted by the Army, Navy, and Air Force. Testing of the Kestrel by each of these Armed Services was necessitated because of their differing military missions, and accordingly, different guidelines were used by each service in evaluating the aircraft. At the time of the National Trials, there was no uncertainty as to the ability of the accused Kestrel to perform as a V/STOL aircraft.

30. (a) A series of fight tests of the Kestrel was made by the Army at Fort Campbell, Kentucky, to examine the applicability of a vertical flight, short takeoff, and landing V/STOL-type aircraft to the Army's needs.

(b) The suitability of the Kestrel for Naval operations was unknown and had not been explored by the tripartite squadron. A series of carrier evaluations of the Kestrel was made to ascertain its suitability for use by the Navy.

(c) Thereafter, the Kestrel was evaluated by the Air Force to ascertain its suitability in a close-support role, as part of a materiel and operational evaluation. The Air Force did not consider the Kestrel to be an operational aircraft, and the flights of the Kestrel did not qualify it for operational use by the Air Force.

(d) The Air Force evaluation concluded the National Trials. One of the five Kestrels was then flown to NASA's Langley Research Center. The officially stated purpose of NASA's initial use of the Kestrel was to provide design and planning information with respect to operating problems, flight techniques and handling qualities, pilot displays, and guidance approach requirements, in order to minimize the time, fuel consumption, and airspace required for high-performance instrument flights to a landing. In

short, the purpose of the NASA program was to explore the parameters of an instrument landing and takeoff of a V/STOL-type aircraft.

At the time of these NASA flights, the information being sought was unknown and had never been obtained. It was determined by NASA that, in order to obtain the desired information, there was no alternative to carrying out actual flights, even though the Kestrel lacked the type of stability system required in an operational aircraft. The NASA work extended up to and beyond the expiration date of the patent. An operating Kestrel aircraft is still being maintained by NASA at Langley Air Force Base.

(e) After completion of the National Trials, four Kestrels were assigned to the Air Force Systems Command at Edwards Air Force Base, for the purpose of acquiring information on performance, handling qualities, and human factors applicable to a nonautostabiiized vectored thrust V/STOL aircraft concept. At the time of the handling-qualities evaluation at Edwards Air Force Base, it was known that a pilot could control an unaugmented and nonautostabilized Kestrel because United States pilots had previously accomplished this feat during the tripartite trials. However, the reason why a pilot can successfully fly an aircraft like the Kestrel, when everything which has gone before indicated it could not be done, was unknown. It was therefore important to the Air Force to obtain data that defined the flight behavior of this aircraft.

When results of the first tests on handling qualities were evaluated, it was clear that additional tests would be needed to fully evaluate the Kestrel. A series of follow-on tests was then made to quantify problem areas that had been qualitatively detected during the earlier handling-qualities tests.

31. Neither the National Trials nor the subsequent test-and-evaluation programs were for the purpose of determin-

ing whether the Kestrel could perform as a V/STOL aircraft. The Kestrel's ability to perform these functions, and the pilot's ability to handle the aircraft, had been proven and accepted by the United States prior to bringing the Kestrels to the United States.

32. The Kestrel was demonstrated during the National Trials and at Edwards Air Force Base for senior officials, and also to the public, during several free air shows on Armed Services Day.

33. The operation and use of the Kestrels in the United States prior to June 17, 1969, involved an expenditure of substantial sums of money. Each agency and service for which the Kestrel was flown, used the aircraft in furtherance of its mission and goals, and the experience and data generated thereby served a valuable governmental purpose. No aspect of the Kestrel's operation in the United States was for amusement or for the purpose of satisfying intellectual curiosity.

Ultimate Findings and Conclusions

1. The specification of the Douglas patent contains a written description of the invention in sufficiently full, clear, concise, and exact terms as to enable any person skilled in the art to make and use the same.

2. The invention described in the Douglas patent is operative and possesses utility.

3. The differences between the subject matter of claim 1 and the prior art are such that the subject matter as a whole would have been obvious in October 1945 to a person having ordinary skill in the art.

4. Claim 1 reads on the accused structures; the accused structures do the same work in substantially the same way and accomplish substantially the same result as the claimed combination and are an infringement of claim 1.

5. The demonstration of the Harrier aircraft in May 1969 was not a manufacture or use by or for the United States.

6. Defendant's use of the Kestrel aircraft and Pegasus engines was not an experimental use of the type that would excuse defendant from liability.

CONCLUSION OF LAW

Upon the foregoing findings of fact and opinion, which are made a part of the judgment herein, the court concludes as a matter of law that plaintiff is not entitled to recover, and plaintiff's petition is dismissed.

APPENDIX B

IN THE UNITED STATES COURT OF CLAIMS

No. 197-70

(Decided January 22, 1975)

AUBREY E. DOUGLAS v. THE UNITED STATES

Robert B. Russell, attorney of record, for plaintiff. *Russell & Nields*, of counsel.

Donald E. Townsend, with whom was *Assistant Attorney General Carla A. Hills*, for defendant.

Before DURFEE, *Senior Judge*, KASHIWA and KUNZIG, *Judges*.

OPINION

PER CURIAM:* In this suit under 28 U.S.C. §1498, plaintiff seeks reasonable and entire compensation for the alleged unauthorized use by defendant of an invention described and claimed in his U.S. Patent No. 2,601,104, entitled "Jet Propulsion and Control Means Therefor," issued June 17, 1952. Jurisdiction is acknowledged and ownership of the patent is uncontested.

The suit involves jet-propelled airplanes. Accused to infringe are six British-made airplanes (called the Kestrel) and 11 replacement engines (called the Pegasus) that were brought to this country by defendant in late 1965. In

* This opinion incorporates the greater part of the opinion prepared by Trial Judge Hal D. Cooper, with modifications and additions by the judges. The Trial Judge considered the issue of the invalidity of the patent and held that it was invalid. He then went on to consider whether, in the event the patent was held to be invalid, there was an infringement. Since this court holds that the patent was invalid, we do not decide the second issue.

addition, plaintiff alleges infringement by reason of the production version of the Kestrel (renamed the Harrier) being demonstrated by the Britsh in this country in May, 1969. Defendant asserts invalidity of the patent on the grounds of lack of utility under 35 U.S.C. § 101, insufficient disclosure under 35 U.S.C. § 112 and obviousness under 35 U.S.C. § 103. In addition, defendant urges the defenses of noninfringement and absence of liability by reason of "experimental use." During pretrial proceedings, claims 1-3, 5 and 8 were alleged to be infringed.[1] However, plaintiff's brief and proposed findings are restricted to claim 1. Accordingly, only that claim will be considered herein.

For the reasons stated hereinafter, we find that claim 1 is invalid for reasons of obviousness. It is not necessary for the court to rule on the defenses of noninfringement and absence of liability by reason of "experimental use" urged by the defendant.

Jet engines employ a jet pipe or tube through which hot combustion gases are directed to produce the thrust required to propel an airplane. Normally, the jet pipe opens rearwardly of the plane so that the propelling gases issue from the jet pipe in a direction opposite to the line of forward flight of the airplane. This suit is concerned with the manner in which the thrust generated by a jet engine may be used, in addition to propelling the aircraft in the normal forward direction, to alter the conventional mode of takeoff and landing. Reference will be made to VTOL, STOL and V/STOL. The term VTOL indicates "vertical takeoff and landing" and refers to the takeoff or landing of a fixed-wing aircraft by only vertical movement of the aircraft. The term STOL indicates "short takeoff and landing" and refers to a fixed-wing aircraft that either

[1] Since references to the several claims and the various figures in the patent are made in this opinion, we have reproduced the patent as an appendix to this opinion.

takes off or lands with only a short horizontal run of the aircraft. The term V/STOL indicates "vertical and/or short takeoff and landing" and refers to an aircraft that is capable of operating in both the VTOL and STOL modes. The term "vectored thrust" will be used herein. That term refers to the directional control of the thrust generated by the jet engine whereby the thrust may be directed to a desired angle other than directly rearward of the plane.

The Douglas patent proposes a mechanism for selectively diverting the combustion gases of a jet engine to a direction other than that of their normal flow so that the thrust may be utilized for braking the airplane, or for assisting takeoff or landing, or for control purposes. Three embodiments are disclosed in the patent. The first (Figs. 1 and 2) employs a baffle for diverting at least a portion of the combustion gases from the jet tube to a pivotally mounted conduit. By pivoting the conduit, the thrust of the engine may be directed toward the ground and either forward (to brake the airplane) or backward (for increasing the lift of the plane). The second embodiment (Figs. 3-5) employs, at the exit end of the jet tube, a number of arcuate members nested together and supported on a common pivot to form a curved conduit for directionally controlling the flow of combustion gases for the same purposes as the embodiment of Fig. 1. The third embodiment (Figs. 6 and 7) has the engine mounted transversely of the aircraft with a pivotally mounted L-shaped conduit for directing the thrust of the engine in the desired direction.

In all three embodiments, directional control of the thrust is achieved by some form of a pivotally mounted conduit movable in a plane substantially perpendicular to the wing. By, for example, pivoting the conduit of any one of the three embodiments downwardly and rearwardly, the thrust of the engine produces two rectilinear components, one acting horizontally to move the plane forward and the other

acting vertically to provide life for the plane. This is the concept of "vectored thrust," *i.e.*, the thrust generated by the engine has both magnitude and direction and is resolvable into rectilinear components.

The advantages of vectoring the thrust, as stated in the patent and during the prosecution of the application, are several. By directing the thrust downward and rearward, the forward speed of the airplane may be decreased while the engine is maintained at full power. This has particular advantages during landing in that the increased lift generated by the downward component of the thrust decreases both the plane's landing speed and the length of the landing run. Moreover, by maintaining the engine at full power, it is immediately available in the event of an emergency. During takeoff, the downward component of thrust decreases the speed at which the plane become airborne and thus decreases the length of the takeoff run. In short, and as Douglas stated it in his patent, "a slow running aircraft and a fast running engine is thus made possible."

The sufficiency and operability of the Douglas disclosure

At the outset, defendant argues that the patent is invalid by reason of an inadequate disclosure under 35 U.S.C. § 112. Defendant's attack is based primarily on the absence of any disclosure in the patent regarding the many technological problems encountered and solved by the Britsh company in producing the accused Kestrel and Harrier airplanes. However, a patent specification is not required to be a production blueprint for constructing a jet airplane. *Trio Process Corp.* v. *L. Goldstein's Sons, Inc.*, 461 F. 2d 66, 74 (3d Cir. 1972), *cert. denied*, 409 U.S. 997 (1972). Nor can a patentee be expected to foresee every technological problem that may be encountered in adapting his idea to a particular use. Some experimentation and exercise of judgment is to be expected. *Binks Manufacturing Co.* v.

Ransburg Electro-Coating Corp., 281 F. 2d 252, 257 (7th Cir. 1960), *appeal dismissed*, 366 U.S. 211 (1961); *International Nickel Co.* v. *United States*, 175 U.S.G.P.O. 209, 214-15 (Trial Div. Ct. Cl. 1972). Giving due regard to the subject matter involved and the circumstances existing in 1945 when the application was filed, *Bowser, Inc.* v. *United States*, 181 Ct. Cl. 834, 388 F. 2d 346 (1967), the disclosure adequately describes a mechanism for directionally controlling the thrust of a jet engine.

Defendant's argument that the patent fails to disclose a device that is sufficiently operative to satisfy the "useful" requirements of 35 U.S.C. § 101 is equally without merit. Plainly, the disclosed device is capable of performing the function attributed to it, that is, directionally controlling the thrust of a jet engine. The mere fact that problems may be encountered in adapting the device to a particular airplane having particular characteristics or that in one mode of its operation some additional controls would be required does not detract from the overall operativeness of the device. *Hildreth* v. *Mastoras*, 257 U.S. 27, 34 (1921).

Obviousness of claim 1

Defendant's principal attack on the validity of the patent is the contention that claim 1 merely defines subject matter that would have been obvious within the meaning of 35 U.S.C. § 103. Although the resolution of the obviousness issue is ultimately one of law, certain basic factual inquiries must be made to set the context for the ultimate legal conclusion. *Graham* v. *John Deere Co.*, 383 U.S. 1, 17 (1966).

a) *The prior art*

Douglas was not the first to propose the idea of directionally controlling the thrust of a jet engine either to brake or increase the lift of an airplane. As early as 1918, in British Patent No. 118,123 granted to Harris, a jet engine

for propelling an airplane was disclosed. That patent specifically proposed that the tubes through which the propelling gases passed could be:

> * * * angularly movable in a vertical direction on horizontal trunnions or pivots for enabling or assisting the aeroplane to rise or descend, and/or the tube may be movable laterally for enabling or assisting the aeroplane to turn. Normally of course the tube would occupy a position in which the aeroplane would be propelled horizontally in a straight path, and to change the movement of the aeroplane means may be provided to enable the pilot to readily alter the position of the tube as required. The tube may be moved to discharge the stream in the front of the aeroplane to produce a braking action and thus retard the speed of the aeroplane when landing.* * *

The prior patents to Anxionnaz (No. 2,396,911), Meyer (No. 2,420,323), and Lysholm (No. 2,280,835), and the text, GAS TURBINES AND JET PROPULSION FOR AIRCRAFT by Smith, all disclose, broadly, the concept of vectoring (*i.e.*, directionally controlling) the hot combustion gases of a jet engine. Lysholm, like Harris, suggests that directional control of the gases may be employed either for increasing the lift or for braking the aircraft. Anxionnaz, Meyer, and Smith disclose deflection of the hot gases for increasing the lift or for maneuvering the aircraft. The Higby patent (No. 1,704,985), instead of vectoring hot gases, discloses the concept of vectoring cold air from a centrifugal fan for imparting lift and assisting in maneuvering the airplane.

These prior art patents disclose a variety of ways for deflecting or vectoring the thrust. Anxionnaz uses shutters or flaps; Lysholm employs fixed conduits and flow control valves for channeling the thrust through the selected conduit; a swivelling nozzle is disclosed in the Smith text;

in Harris, the jet tubes are pivotally mounted; and in Higby, pivoting conduits are used. Lysholm specifically discloses that defiection of the jet thrust will result in a fast running engine and a slow moving aircraft; that result is also inherent in both Harris and Meyer.

b) *Differences between the prior art and claim 1*

The functional concept expressed in claim 1 is that of diverting the combustion gases from a jet engine "to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft." This concept is expressly disclosed in the Harris patent. The differences between the Harris patent and claim 1 reside in the specific means for diverting the combustion gases. In particular, claim 1 specifies three elements: (a) means for diverting the gases from the jet tube, (b) a discharge conduit for receiving the diverted gases, and (c) means mounting the discharge conduit for pivoting movement. Harris does not disclose any means for diverting the gases from the jet tube; rather, Harris contemplates that the jet tube itself would be pivotally supported and would be used as the discharge conduit. Harris' arrangement would necessarily have the outlet of the jet tube "movable about an axis in an arc of approximately 180°, in a plane substantially perpendicular to the plane of the wing" as called for in claim 1.

The Higby patent differs from the combination of claim 1 in two respects. By specifying "combustion gases," it is implied in claim 1 that the propelling jet is a jet engine; Higby utilizes a cold air centrifugal fan. Higby also differs from claim 1 in that the range of movement of the pivotable conduits in Higby would not be sufficient to direct the thrust in a forward direction to achieve a braking reaction. However, Higby does disclose a means for diverting flow of a gas from a rearward direction, a discharge conduit for receiving the diverted gases, and means mounting the discharge conduit for pivoting movement for directional control of those gases.

c) *Level of skill in the art*

The first flight of a jet-propelled airplane occurred in 1939. In 1941, as a result of development work commencing in the late 1920's, the British flew their first jet airplane. The design of the powerplant used in that airplane subsequently was brought to the United States, and by late 1943 and early 1944, jet airplanes had been designed, built, and flown in this country. Thus, as of October, 1945, the field of jet propulsion, although in its infancy, had evolved into a working reality and had become a specialized part of the larger field of aircraft powerplants. In view of its obvious complexities, the level of skill of those working in that field must be considered to be relatively high. *Westinghouse Electric Corp.* v. *Titanium Metals Corp. of America,* 454 F. 2d 515 (9th Cir. 1971), *cert. denied,* 407 U.S. 911 (1972), although less well developed than when the accused structures were produced. At the least, the level of skill in 1945 had progressed beyond that represented by the disclosures of the prior art references discussed herein.

d) *The obviousness determination*

At the outset, it is necessary to address a matter not heretofore mentioned but which appears to be the major argument advanced by plaintiff for nonobviousness. Plaintiff contends the Douglas patent discloses that the resultant force of the deflected jet thrust must pass "near to or through the center of gravity of the aircraft." This feature, plaintiff asserts, is "the patentee's vital contribution to the art" and is "essential" to the success of a V/STOL airplane.

There are two difficulties with this argument. The first is that the Douglas patent nowhere discloses that the resultant force must pass through or near to the center of gravity either of the engine or of the aircraft. Indeed, during the prosecution of the patent, Douglas attempted to amend his

disclosure to include this "teaching" but the Patent Office required its cancellation on the basis that it was not disclosed in the application as originally filed. Obedient to this requirement, and without argument, Douglas canceled the amendatory material.

Figure 6 of the patent does pictorially illustrate an arrangement in which the resultant force would act through the center of gravity. However, that showing does not aid plaintiff in his argument. Neither the elected species of Fig. 1, nor the embodiment of Fig. 3, disclose such a relationship. Since two of the three embodiments disclosed do not illustrate that relationship, it can hardly be said that the patent teaches that the resultant *must* act through a certain point.[2]

Thus, it is attributing too much to Douglas to assess the obviousness of his contribution, as defined by claim 1, in the context of an airplane in which the proper relationship between the vectored thrust and the center of gravity is maintained. The facts are that Douglas only proposed a solution to the problem of how, mechanically, to directionally vary the thrust, not how to vary the thrust while maintaining controllability of the aircraft. From the standpoint of adequacy, the specification will permit no broader interpretation. The pictorial illustration of Fig. 6, from which it may be *inferred* that the thrust acts at or near to the center of gravity, is impractical.

The second difficulty with plaintiff's argument is that this vital feature is not covered by claim 1. The arrangement of Fig. 6 falls outside the language of the claim, which requires the jet tube to be parallel to the line of flight. Moreover, the only claim that specifically defines the point through

[2] There is some evidence that one ordinarily skilled in the art in 1945 would understand that the embodiments of Figs. 1 and 3 should be so arranged that the resultant would act through the center of gravity. That evidence, while helpful to plaintiff on the question of operativeness, is contrary to plaintiff's nonobviousness contentions.

which the resultant acts is dependent claim 8 wherein the resultant is described as passing through "a point between the leading and trailing edges of the wing." However, even that limitation does not describe the resultant as passing through the center of gravity of the aircraft since, in conventional aircraft, the center of gravity is located at the quarter chord of the wing.

The claims are the measure of the invention and resolution of the obviousness question must be based on what is claimed. *Kemode Manufacturing Co.* v. *United States,* 171 Ct. Cl. 698, 347 F. 2d 315 (1965). Since Douglas only discloses, and claims, a mechanism for varying the thrust of a jet engine to achieve certain results, but has left it to those in the art to determine how to accomplish that without adversely affecting the controllability of the airplane, it is in that context that obviousness must be determined. Turning then to claim 1, it is apparent from the foregoing analysis of the prior art that the Harris patent discloses the basic concept of vectoring the jet thrust to provide either lift or braking. This basic concept being known, the remaining aspects of the claim relate only to the mechanics by which the thrust is directionally controlled.

The prior art discloses a variety of ways for directionally controlling the propelling thrust in an airplane. Harris discloses pivoting the jet tubes for that purpose. While Harris is ambiguous in that it is unclear whether the entire engine would be pivoted with the tubes or the jet tubes would pivot independently of the engine, this does not alter the pertinence of that reference. Even it is assumed that Harris intended the engine to pivot as a unit with the tubes, Higby discloses a mechanism for maintaining the engine stationary while directionally controlling the thrust. In view of Higby, the conclusion is inescapable that one skilled in the art who wanted to accomplish the objectives of

Harris, but without pivoting the engine, would find it obvious to use the independently pivotable conduits disclosed by Higby. No new and unobvious function would result from such a modification of Harris.

Given the relatively high level of skill in this particular art, given the suggestion in Harris for pivotally supporting the jet tube, and given the disclosure of the Higby patent in which pivotally mounted conduits are plainly disclosed, it must be concluded that it would have been obvious in 1945 that the claimed arrangement of conduits could be used to control the direction of the thrust.

In reaching this conclusion, due regard has been given to the presumptively correct decision of nonobviousness implicit in the patent examiner's allowance of this patent. However, neither Harris nor Higby was cited by the examiner. Where, as here, the most pertinent prior art references were not cited by the examiner, the presumptions to which the patentee is entitled are greatly weakened, if not entirely overcome. *Nossen* v. *United States,* 189 Ct. Cl. 1, 416 F. 2d 1362 (1969), *rehearing denied,* 191 Ct. Cl. 198, 422 F. 2d 1340 (1970), *cert. denied,* 400 U.S. 823 (1970).

As a means of guarding against "slipping into use of hindsight," *Monroe Auto Equipment Co.* v. *Heckethorn Manufacturing & Supply Co.,* 332 F. 2d 406, 412 (6th Cir. 1964), *cert. denied,* 379 U.S. 888 (1964), the secondary considerations urged by plaintiff in support of nonobviousness have also been carefully reviewed. In large part, these are based on the undisputed success of the Kestrels and Harriers which were the first usable aircraft with V/STOL capabilities and which are the only operational aircraft with that capability even today. However, to be of any value on the issue of obviousness, success must be attributable to the *claimed* invention and not to other factors. *Palmer* v. *United States,* 182 Ct. Cl. 896, 904 (1968). Here, the evidence

shows that other factors are highly significant to the success of those airplanes.[3]

As noted previously, a major consideration in V/STOL airplanes is the pilot's ability to control the airplane during vectoring of the thrust. Controllability was achieved in the accused planes in two ways. The first was the use of four nozzles so arranged that the resultant force of the vectored jets acted at or near to the center of gravity of the airplane. The other was the use of a system of puffer jets to provide an auxiliary control. Neither of these is disclosed nor claimed in the Douglas patent.

In summary, Douglas proposed a specific mechanism for accomplishing the objectives earlier suggested by Harris. The mechanism itself was an obvious variation of that previously suggested by Higby. Nonobviousness, if any, lay not in the mechanism but in the manner in which the mechanism was used in an airplane to vary the thrust direction while maintaining controllability of the airplane. The builders of the accused Pegasus, by expending some $70 million in the development of that engine, solved that problem, not Douglas. Having contributed nothing to the development of the critical relationship, Douglas cannot rely on the subsequent success of the accused airplanes to sustain the validity of his patent.

Claim 1 is invalid under 35 U.S.C. § 103. The patent being invalid, the petition must be dismissed.

FINDINGS OF FACT

1. U.S. Patent No. 2,601,104, entitled "Jet Propulsion and Control Means Therefor," issued June 17, 1952, on an application filed September 10, 1946. The patent claims the priority date of British Patent No. 643,969, filed in Great Britain on October 15, 1945.

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[3] Although plaintiff did disclose his ideas to the British company that designed the Pegasus, there is no evidence that any use was made of those disclosures by that company.

2. Aubrey E. Douglas, an individual, is a British subject residing at Saltford Farm, Somerset, England. Plaintiff Douglas' ownership of the patent has not been contested in this suit. Plaintiff did not appear at the trial, defendant having waived its right to require his presence.

Disclosure of the patent

3. The problem of controlling a jet aircraft is particularly critical at slow speeds when the effect of the airfoil surfaces is less due to the reduced velocity of the air passing over them. Thus the control of all fixed-wing aircraft is said to be "sluggish" as the aircraft approaches the stall speed. This problem is compounded in jet-propelled fixed-wing aircraft by the fact that jet engines do not accelerate rapidly. Thus, if the pilot desires a sudden burst of power from the engine, as in a balked landing situation, a jet engine is poorly equipped to provide it. As a result, jet aircraft have been required to land at high speed, to the detriment of certain other safety factors, and with the requirement of long landing fields.

4. The patent in suit discloses apparatus for the control of jet-propelled aircraft during takeoff, landing, and while airborne. In particular, Douglas' idea was to divert the efflux of the jet away from the normal rearward direction, to various other directions including downward and rearward, directly downward, downward and forward, and/or directly forward so as to provide lift and/or braking components of reaction, while still maintaining the operation of the engine at full power and available for redirection to provide normal forward thrust, if desired. A slow moving aircraft and fast running engine are thus made possible by the deflection of the jet stream.

5. (a) Three embodiments for controlling the direction of the output combustion gases from a jet engine are disclosed and illustrated. The embodiment shown in Figs.

1 and 2 employs a baffle D for diverting at least a portion of the combustion gases from the normal rearward direction of flow in jet tube C into conduit E, and thence into pivotably mounted conduit H. Conduit H may be pivoted through a range of about 40° in order to vector combustion gases either forwardly (for braking) or downwardly (for additional lift).

(b) In the second embodiment (Figs. 3-5), the jet tube terminates in an elbow joint formed from a number of arcuate members constructed to nest together in order to form a curved conduit. This elbow joint deflects the combustion gases downwardly from their normal "straight through" rearward flow, to any point on an arc of 180°.

(c) The third embodiment (Figs. 6, 7) shows a jet engine A mounted in the wing of an aircraft. The longitudinal axis of engine A is transverse to the long axis or horizontal center line of the aircraft. The engine is provided with a conduit or tube C. In forward flight, the normal position of the jet tube C is directly rearward. By pivoting the tube C through any chosen degree in an arc of 0° to 110°, the direction in which the combustion gases are discharged may be varied.

(d) The first two embodiments utilize essentially three components:

(i) a jet tube through which the gases normally discharge for propulsion of the aircraft;

(ii) means for diverting the gases from their normal rearward direction; and

(iii) a movable conduit that receives the diverted gases and directs them to the desired direction.

In the embodiment of Fig. 6, all three components are combined into a single element, the pivotably mounted L-shaped conduit C.

6. The Douglas patent discloses a vectored thrust principle in which direction other than the normal rearward

direction may be imparted to the thrust generated by the hot combustion gases from a jet engine.

7. In any airplane, it is important that the resultant of the jet thrust forces pass through or near to the center of gravity (c.g.) of the airplane. If, by vectoring the jet thrust, the resultant force passes to the rear of the c.g. of the airplane, a nosedown attitude will be imparted to the aircraft which, if not corrected, will cause the aircraft to nosedive. The need for the resultant forces to pass through the c.g. is particularly critical when a plane is operated in the VTOL mode because there is no airflow over the ailerons and rudder which would enable the pilot to use those controls to maintain the correct attitude of the airplane. This is less critical during STOL operation where there is airflow over the control surfaces.

8. The Douglas specification contains no mention of the relationship between the resultant of the vectored thrust and the center of gravity. During prosecution of the patent, Douglas attempted to amend his specification to include the statment that "the reactionary effect gen- to include the statement that "the reactinary effect generated by the diversion of the jet should pass through the proximity of the center of gravity of the aircraft." The examiner required cancellation of this statement, holding that it was new matter, and Douglas did not contest that requirement. The examiner did permit Douglas to insert a claim (claim 8) that calls for the reaction of the vectored jet to pass "through a point between the leading and trailing edges of the wing." However, that point is not necessarily coincident with the center of gravity which, in conventional aircraft, is normally located at the quarter chord of the wing.

9. The embodiments of Figs. 1 and 3 of the Douglas patent do not show the resultant force as passing through the center of gravity of the aircraft. The embodiment of

Fig. 6 does illustrate an arrangement in which the resultant force acts near the center of gravity. Figs. 1 and 3 employ a double 90° bend for the gases; Fig. 6 has a single 90° bend.

10. Each of the disclosed embodiments could, with appropriate balancing of forces and suitable controls, be used both in the VTOL and STOL modes.

Sufficiency and operativeness of the disclosure

11. The patent in suit discloses a workable arrangement for directionally controlling the jet thrust and one that would be understood by those ordinarily skilled in the art. Those in the art would understand that, to achieve a controllable aircraft, it would be necessary, in addition, to minimize pitching moments about the center of gravity of the aircraft created by varying the direction of the jet.

12. Douglas submitted his ideas to Vickers-Armstrong Ltd. in 1948. That company designed an airplane based on Douglas' idea. Although the airplane was never built, there is no evidence that the company had any difficulty in understanding the idea. None of the other companies or organizations to which Douglas disclosed his idea expressed any lack of understanding as to its operativeness or utility.

The scope and meaning of the claim

13. Claim 1, the only claim now asserted by plaintiff, provides as follows:

> Apparatus for controlling the reaction of a propelling jet in a rigid wing aircraft, comprising a jet tube mounted approximately parallel to the line of flight, means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal, a discharge conduit associated with the jet tube adapted for receiving the diverted gases, the discharge outlet of

patents to Anxionnaz and Meyer, as well as the text GAS TURBINES AND JET PROPULSION FOR AIRCRAFT by Smith, disclose the concept of deflecting the jet to assist in maneuvering the aircraft. Vectoring of the gases in both Higby and Lysholm, as well as in the early patent to Valdez (No. 1,629,767), was accomplished by passing the gases through two bends.

17. Various techniques for deflecting or vectoring the jet thrust were known prior to the Douglas patent. One technique was the use of shutters or flaps (Anxionnaz); another was the use of fixed conduits and flow control valves (Lysholm); still another was the use of a swivelling nozzle (Smith text, Plaintiff's Exhibit 24A); a further technique was pivotably mounting the jet tubes (Harris); another was the use of pivotally mounted L-shaped conduits (Higby; Valdez).

18. The patents to Anxionnaz, Lysholm, Meyer, and Valdez were cited by the Patent Office during prosecution of the Douglas patent. The Harris and Higby patents were not cited.

19. The manner in which the jet tubes in the Harris patent would be pivoted is ambiguous. Although suggesting the use of trunnions as pivots for the jet tubes, it is unclear whether the tubes would pivot independently of the remainder of the engine or the engine would pivot with the tubes.

20. The use of pivotably mounted conduits for directionally controlling the discharge of gases, with the conduits being selectively movable about an axis in a plane substantially perpendicular to the plane of the wing, is disclosed in both the Harris and Higby patents.

21. By late 1943 and early 1944, jet airplanes had been designed, built, and flown in this country. By October, 1945, the field of jet propulsion had become a specialized part of the larger field of aircraft powerplants. The level of

skill of those working in that specialized field as of that date was relatively high.

Differences between prior art and claim 1

22. (a) Claim 1 does not require that the jet engine remain stationary. The claimed concept of diverting combustion gases in an arc to effect, in at least one position, a braking reaction on the aircraft is disclosed in the Harris patent. The combination of claim 1 differs from Harris only in the specific mechanical means employed to divert the combustion gases through the desired arc. In particular, Harris does not disclose any means for diverting the gases from the jet tube; rather, Harris would direct the gases by pivoting the jet tube itself, a concept similar to Fig. 6 of the Douglas patent. In fact, to the extent claim 1 is readable on Fig. 6, it is also readable on the Harris patent.

(b) The combination of claim 1 differs from Higby only in the type of propelling jet employed and the degree of rotation of the discharge conduit. Higby contemplates the use of cold air instead of hot combustion gases; nor does Higby contemplate pivoting the discharge conduits to a forward position to impart a braking reaction. Higby discloses the same essential combination of elements for directionally controlling the propelling jet as that employed in the Douglas patent and the accused aircraft, *i.e.*, (i) a means for diverting the flow, (ii) a discharge conduit for receiving the diverted gases, and (iii) means mounting the discharge conduit for pivoting movement about an axis in a plane substantially perpendicular to the plane of the wing. As in Douglas, the gases in Higby would pass through two 90° bends.

Other considerations bearing on validity

23. (a) Based on Douglas' ideas, Vickers-Armstrong proposed an airplane in which the jet thrust could be deflected up to 60°. In order to obtain the proper balance

of forces and avoid the introduction of pitching moments about the c.g. when the jet was deflected, very substantial modifications in the airplane were proposed. Even then, the airplane would have had no VTOL capability. This proposal did not progress beyond the preliminary design stage.

(b) It was not until the advent of the light weight gas turbine engines having a high thrust-to-weight ratio that it became apparent that rigid-wing aircraft with V/STOL capability could be built. Starting in about 1952, essentially four approaches were taken by the industry: tilt thrust (the wings and/or the engines are tilted to direct the thrust in the desired direction); augmented thrust (lift fans are driven by the engines to generate the lift); dual propulsion (separate engines for lift and for propulsion are used); and vectored thrust (represented by the accused airplanes).

(c) Development in the United States was concentrated in areas other than vectored thrust. By 1969, some 12-15 development programs, at a cost of millions of dollars, had been undertaken in the United States in an attempt to produce a satisfactory V/STOL airplane. None of those programs was successful in terms of producing a usable aircraft.

(d) A fundamental problem in vectoring the thrust of a propelling jet is in maintaining the controllability of the airplane as the direction of the thrust is varied. Those in the art recognized that directional control of the thrust could be achieved without adversely affecting the trim so long as the resultant force always passed through or near to the center of gravity; however, as indicated by the substantial modifications proposed by Vickers-Armstrong in the hope of accomplishing this goal, this was difficult to achieve. Douglas' only suggestion for achieving this critical relationship is contained in Fig. 6 where the engine is

located transversely of the airplane, approximately in line with the c.g. of the aircraft; however, the transverse mounting of the engine is impractical.

(e) The British-made Kestrel and Harrier aircraft, using the vectored thrust principle, are the only usable V/STOL aircraft that have been developed and built to date. Approximately 2.5 million technical man hours, at a cost of approximately $70 million, were expended in developing the Pegasus engine used in the Kestrel aircraft. Although Douglas did disclose his ideas to the builder of the Pegasus engine, there is no evidence that any use was made of that disclosure.

ULTIMATE FINDINGS AND CONCLUSIONS

1. The specification of the Douglas patent contains a written description of the invention in sufficiently full, clear, concise, and exact terms as to enable any person skilled in the art to make and use the same.

2. The invention described in the Douglas patent is operative and possesses utility.

3. The differences between the subject matter of claim 1 and the prior art are such that the subject matter as a whole would have been obvious in October, 1945 to a person having ordinary skill in the art.

CONCLUSION OF LAW

Upon the foregoing findings of fact and opinion, which are made a part of the judgment herein, the court concludes as a matter of law that plaintiff is not entitled to recover, and plaintiff's petition is dismissed.

Patented June 17, 1952

2,601,104

UNITED STATES PATENT OFFICE

2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Aubrey Douglas, Saltford, England

Application September 10, 1946, Serial No. 695,839
In Great Britain October 15, 1945

8 Claims. (Cl. 244—12)

1

This invention relates to jet propulsion for aircraft and is particularly concerned with a method of and means for controlling the propulsive effort created by the efflux or jet whereby a reverse action is obtainable.

According to the invention, a method of controlling the reaction jet of a jet propelled or partially jet propelled aircraft consists in baffling or reducing the effective area of the jet nozzle and/or diverting partially or otherwise the combustion gases in a direction other than the normal direction of flow.

It is to be understood the aforesaid method is additional to the normal means of controlling the efflux.

The invention also comprises means for baffling the efflux from a jet nozzle or for reducing the effective area of said nozzle and diverting the combustion gases, by means, for example, of ducts or conduits, in a direction other than that of their normal flow whereby the reaction created may be utilized for braking purposes, for assisting take off or landing or other control purposes.

In order that the invention may be clearly understood and readily carried into effect, reference is directed to the accompanying drawings, wherein:

Fig. 1 illustrates diagrammatically in plan view partly in section, a part of an aircraft wing embodying the invention.

Fig. 2 is a section on the lines 2—2, Fig. 1, looking in the direction of the arrows.

Figs. 3, 4, 5 illustrate a side elevation, a longitudinal section and a cross-section along the line 4—4 of Fig. 4 respectively of a modified form of a diversion means according to the invention.

Fig. 6 is a plan view of a wing and part of a fuselage of a jet propelled aircraft showing an application of the invention thereto and embodying a modified form of the invention.

Fig. 7 is a section on the line 13—13, Fig. 6.

The drawings are essentially diagrammmatic and the same reference characters are used throughout the figures for the same or equivalent parts.

The form of the invention illustrated in Figs. 1 and 2 of the drawings is applied to an aircraft in which a jet propulsion unit A is mounted in a wing B and consists in disposing in the main jet tube C, a baffle or diaphragm D associated with means (not shown on drawings) whereby it may be gradually introduced into the gas stream or closed thereon to divert its force, the cross-section of the jet tube being suitably shaped to receive the baffle. The combustion gases so diverted are lead by one or more ducts or conduits E, each having an outlet F to the inlet G of a discharge conduit H, the outlet J for the said conduit H pointing in any required direction, for example, forward and/or downward for the purpose of checking the speed of the aircraft or increasing its lift.

2

The outlet J of the conduit H is directionally controlled so that the resultant force thereof will act in the plane or in planes parallel to the plane of symmetry of the aircraft, so that the diverted gases may be directed towards the ground and forward or backward as required for increasing the lift at braking or taking off respectively as illustrated in Fig. 2. For this purpose, the conduit H is mounted in bearings K, L, a trunnion M integral with the conduit H resting in the bearing K and the inner end of the conduit H being mounted in the bearing L. In order to rotate the conduit H along its path of movement, a pinion N is secured to the inner end of the conduit H, a suitable means being furnished to actuate the said pinion to effect the required disposition of the conduit H.

The conduit E may be lead straight into the conduit H or as an optional feature as shown in Fig. 1 of the drawings, the inner end O of the conduit H may be splayed to receive the outlet end F of the conduit E, thus introducing an ejector drawing air, for example, from a boundary layer into the chamber O and from there into the conduit H. The conduit H is normally housed within the wing structure, the lower face of which is fitted with doors P which are dropped when it is desired to bring the conduit into position for operative purposes. The outlet J of the conduit may be furnished with a closure Q.

The invention is applicable to all forms of jet propulsion units whether mounted in the aircraft wings or in the fuselage of an aircraft, the ducts or conduits being disposed in the most suitable position in relation to the propulsion unit subject to the inlets being arranged in the discharge conduit and the outlet in such a position as to create a rectionary effort, whether directed in axial opposition to the normal jet flow or at an angle thereto, the resultant force being utilized as a means of control.

Figs. 3, 4, 5 show a modification of the invention in which the jet nozzle C has an elbow joint Q formed of a number of members which are capable of nesting together to form a through conduit (see Fig. 4) or being diverted by consorted or independent operation as shown in Fig. 3 to

give a discharge in the reverse direction or in a direction determined by a path of 180° in a plane or in planes parallel to the plane of symmetry of the aircraft through which the nozzle can be turned.

The elbow joint Q comprises four members Q^1, Q^2, Q^3, Q^4, of which Q^1 and Q^4 are fixed to the jet nozzle elements H and C, respectively, permitting the intermediate members Q^2 and Q^3 to be independently operated to an open position to enable quick recovery of the normal jet flow to a comparatively straight line course. Further, all or one of the members Q^1, Q^2 and Q^3 may be slotted to permit partial flow of the gases to reduce the initial pressure at the outlet of the nozzle and obtain a smooth braking effect when the nozzle is brought into use. In effect the elbow constitutes a valve controlling the gas flow. The jet nozzle conduit may also be reduced to provide a Venturi portion as at Q^2 to which inlets Q^4 are made from any suitable surface of the aircraft.

Figure 5 indicates diagrammatically a method of operating the several parts of the elbow. In this figure Q^1 is fixed to the conduit H and operable therewith, Q^2 is secured to a sleeve Q^7, and Q^3 to a shaft Q^6, the member Q^4 being free of the shaft and secured to the jet nozzle.

Figs. 6 and 7 illustrate an arrangement in which the jet propulsion unit A is mounted in a wing B transversely to the thrust and drag line, the nozzle C having an elbow part C^2 which is mounted in a pivotal bearing M such as described with reference to Fig. 1, the inlet end of the discharge nozzle being mounted for rotation in a gland R. The normal position of the discharge nozzle is as indicated in dotted lines in the Figs. 12 and 13, whereas the braking position of the discharge nozzle is indicated in full lines in these two figures. The outlet of the discharge nozzle is fitted with a diffusion cone C^3, this cone may be adjustable, for example, axially slidable or can be rectangular and provided with adjustable louvres.

Broadly speaking, the invention improves the controllability of jet propelled or partially jet propelled aircraft by two methods, one is to decrease the speed at which the machine is airborne, the other is to increase the lift whereby the machine becomes and remains airborne by diverting the normal jet flow to produce two thrust components, one reacting horizontally forward to induce a rearward braking reaction in the machine, the other acting vertically downwards and thereby generating an increased lifting force.

The invention may comprise any number or arrangement of ducts of any suitable cross-section or of variable cross-sectional area, whereby the velocity of the effluent in the conduits may be accelerated or retarded as desired.

Boundary layer tapping is particularly effective when the propulsion unit is running at full speed and is most required when the aircraft is travelling at a comparatively slow speed, for example, at landing; a slow running aircraft and a fast running engine is thus made possible by the deflection of the jet stream.

What I claim and desire to secure by Letters Patent is:

1. Apparatus for controlling the reaction of a propelling jet in a rigid wing aircraft, comprising a jet tube mounted approximately parallel to the line of flight, means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal, a discharge conduit associated with the jet tube adapted for receiving the diverted gases the discharge outlet of said discharge conduit being selectively movable about an axis in an arc of approximately 180°, in a plane substantially perpendicular to the plane of the wing for directionally controlling the discharge of gases from the conduit to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft.

2. Apparatus according to claim 1, wherein in at least another position of the discharge conduit, a braking and lifting reaction on the aircraft is effected.

3. Apparatus according to claim 1, wherein the discharge end of the discharge conduit is movable in a plane parallel to the plane of symmetry of the aircraft.

4. Apparatus according to claim 1, wherein the means for diverting the flow of at least part of the gases, is a valve.

5. Apparatus according to claim 1, wherein the discharge conduit is mounted for pivotal movement.

6. Apparatus according to claim 1, wherein the discharge conduit is mounted for pivotal movement and comprises an elbow joint formed of a number of members capable of nesting together.

7. Apparatus according to claim 1, wherein the discharge conduit is mounted within an aircraft wing structure and the outlet of said conduit, in controlled operative position, is at the under side of the wing structure.

8. Apparatus according to claim 1, wherein the reaction generated by the diversion of the jet passes through a point between the leading and trailing edges of the wing.

AUBREY DOUGLAS

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 23,198	Anxionnaz	Feb. 21, 1950
141,039	Dow	July 22, 1873
141,340	Evans	July 30, 1873
514,527	Wauters	Feb. 13, 1894
1,382,536	Offen	June 21, 1921
1,629,767	Valdés	May 24, 1927
1,642,752	Landon	Sept. 20, 1927
1,714,917	Martin	May 28, 1929
1,813,189	Moore	July 7, 1931
2,024,274	Campini	Dec. 17, 1935
2,280,835	Lyaholm	Apr. 28, 1942
2,420,323	Mayer	May 13, 1947
2,486,272	Gaada	Oct. 25, 1949

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Number	Country	Date
432,727	France	Oct. 17, 1911

A-61

22

June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 1

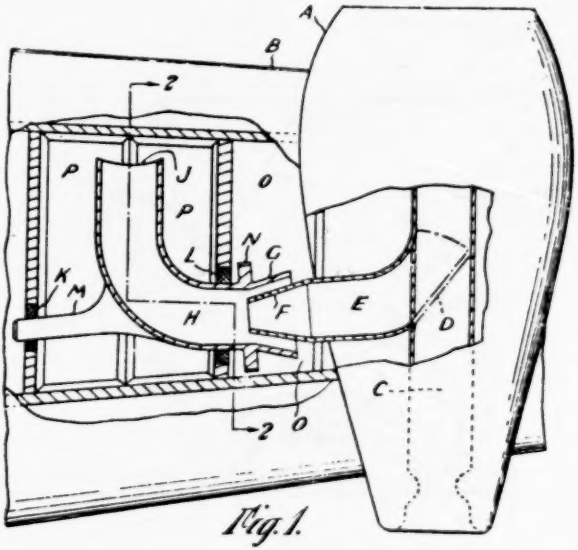

Fig. 1.

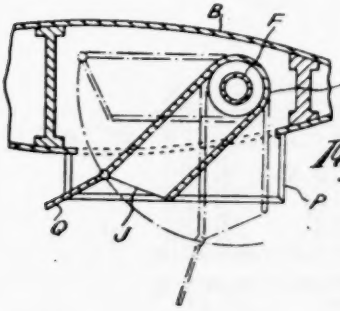

Fig. 2.

Aubrey Douglas

By Cushman, Darby & Cushman

Attys

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June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 2

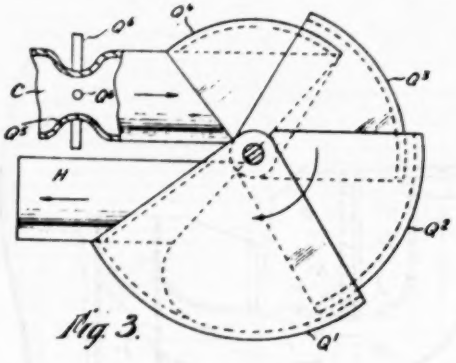


Fig. 3.

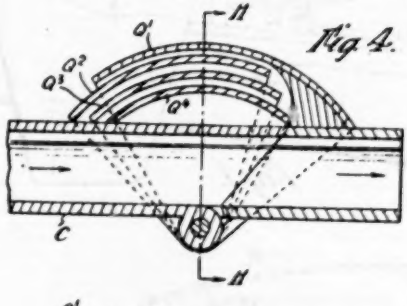


Fig. 4.

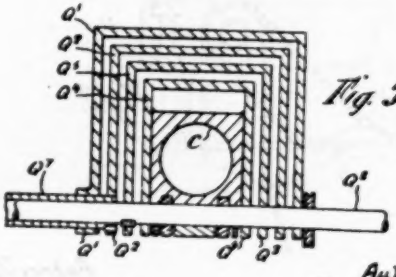


Fig. 5.

Audrey Douglas

By Thurman, Myers, Mosley & Mosley

Atty's

June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 3

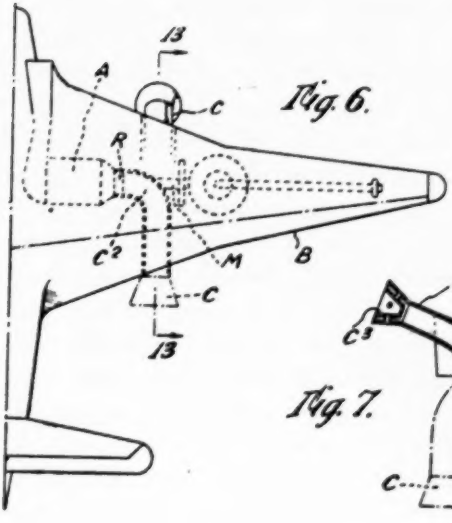


Fig. 6.

Fig. 7.

Audrey Douglas
By Fraser, Myers & Hawley
Atty's

U.S. GOVERNMENT PRINTING OFFICE: 1978

APPENDIX C

CONGRESSIONAL HEARINGS ON THE PROCUREMENT OF THE HARRIER OF MAY 12, 1969 (SELECTED PORTIONS)

[p. 323]

FAILURE TO DEVELOP DOMESTICALLY

Mr. Sikes: In what respects do the aircraft in this general area which have been developed in the United States fail to meet the requirements that you expect to acquire in the Harrier? In other words, I find it hard to understand, when we have been putting money into this concept for 20-odd years to my own knowledge, that we come up with nothing that is usable and we have to go overseas to buy the aircraft. Whose fault is that?

General McCutcheon: I do not think it is anybody's fault, Mr. Sikes. I think in this country the particular techniques that were used and investigated to get the V/STOL did not pan out as well as the vectored thrust principle that is used in the Harrier's engine. We had 12 or 15 different developments in this country, including tilt wings, tilt engines, fanjets, and so forth. Of these, I guess the fanjet shows about as much promise as any.

Mr. Sikes: Did we try to develop in too broad an area? Did we scatter our shot too much? In what way did we fail to accomplish what was desired?

[p. 324]

I still have not had an answer as to why all this developmental effort in the United States was unproductive and we had to go overseas to buy an aircraft.

General McCutcheon: This is a new area. When we started into it, nobody knew exactly what the final outcome would produce, so they had more or less to shoot across a broad spectrum and try all those approaches that appeared technically feasible.

The fact that this one surpassed all the others accounts for the successful accomplishment of the Harrier.
[p. 333]

In all V/STOL development, one of the penalties that has been paid in many of the developments has been the fact that you had to put in a weight penalty to get the aircraft off the ground or to permit it to land. With this engine and this vectored thrust principle, you can use this technique not only for the vertical takeoff and landing, but also for the maneuvering in the air, so you are not paying a weight penalty just for a small percentage of the flight time.

VECTORED THRUST PRINCIPLE

Mr. Rhodes: Because some of the people who read this record may not know what a vectored thrust principle is, would you put something in the record at this point to explain that?

General McCutcheon: Yes, sir.

(The information follows:)

Vectored thrust is a mechanization of turbojet engine exhaust nozzles which provides the capability to direct the engine thrust to desired angles relative to the airframe. Angles which may be selected range from directing the thrust rearward, in which case the vectored thrust aircraft operates the same as any other jet aircraft, to directing the thrust to some angle forward of vertically downward in which case a measure of reverse thrust is provided. When the engine nozzles are directed vertically downward, thrust is provided in the same direction as lift on the airplane wing, and if the magnitude of the thrust is equal to or greater than the weight of the aircraft, it will be capable of taking off and landing vertically. Vectored thrust angles between rearward and vertically downward are usable for "short takeoffs." In

this case the vertical component of the thrust assists the airplane wing in lifting the weight of the aircraft, and the rearward component powers the aircraft as in conventional jet flight.

APPENDIX D

DEFENDANT'S REQUEST FOR FINDING OF FACT NO. 13

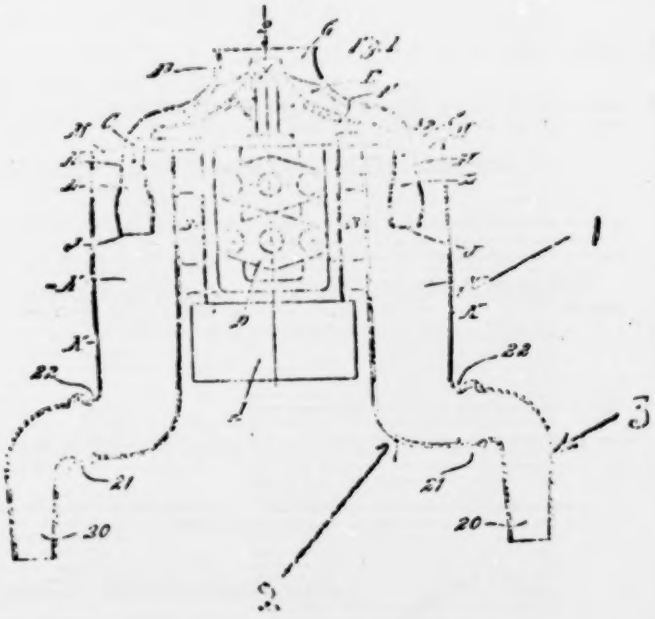
(C) The Discharge Nozzle Of The Articulated Jet Tube In The Douglas Patent Is Located At Or Near The Center Of Gravity Of The Aircraft

(13) According to the plaintiff's expert witness, Mr. Johnson, the Douglas patent discloses that the resultant force of the jet streams from all jet engines on an aircraft has to act in the plane of symmetry (Col. 2). This proves, and plaintiff's expert explicitly so stated, that the component of lift on the Douglas device has to pass through the center of gravity of the aircraft (Johnson Deposition, p. 111). The accuracy of this statement on the relationship between the center of thrust and the center of gravity of an aircraft was further corroborated by another of plaintiff's expert witnesses, Dr. Lancaster, who stated that the fundamental thing involved in the Douglas engine that is different and new, is that the center of thrust in Fig. 6 goes through the center of gravity. Dr. Lancaster emphasized that it is very important for the center of thrust to coincide with the center of gravity (Lancaster, 417-419).

IN THE U. S. COURT OF CLAIMS
NO (S) 177-70
Pltf's Claim Def's Claim
St. No. 26 Pgs. of Tests
for ID. In Evid.

COMPOSITE SKETCH

Harris No 118123 (U.K.)
Higby No. 1704895 (U.S.)



Aubrey Douglas v. U.S.
Ct. Cl. 177-70
DX-26A-for i.d.

2,601,104

UNITED STATES PATENT OFFICE

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas Aubrey Douglas,

of

Saltford, England,

PRESENTED TO THE Commissioner of Patents A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

JET PROPULSION AND CONTROL MEANS THEREFOR,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID

Aubrey Douglas, his heirs OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this seventeenth day of June, in the year of our Lord one thousand nine hundred and fifty-two, and of the Independence of the United States of America the one hundred and seventy-sixth.

Attest:

Law Examiner.

John A. Marzall

Commissioner of Patents

Patented June 17, 1952

2,601,104

UNITED STATES PATENT OFFICE

2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Aubrey Douglas, Salford, England

Application September 19, 1946, Serial No. 696,839
In Great Britain October 25, 1945

8 Claims. (Cl. 244—12)

1

This invention relates to jet propulsion for aircraft and is particularly concerned with a method of and means for controlling the propulsive effort created by the efflux or jet whereby a reverse action is obtainable.

According to the invention, a method of controlling the reaction jet of a jet propelled or partially jet propelled aircraft consists in baffling or reducing the effective area of the jet nozzle and/or diverting partially or otherwise the combustion gases in a direction other than the normal direction of flow.

It is to be understood the aforesaid method is additional to the normal means of controlling the efflux.

The invention also comprises means for baffling the efflux from a jet nozzle or for reducing the effective area of said nozzle and diverting the combustion gases, by means, for example, of ducts or conduits, in a direction other than that of their normal flow whereby the reaction created may be utilized for braking purposes, for assisting take off or landing or other control purposes.

In order that the invention may be clearly understood and readily carried into effect, reference is directed to the accompanying drawings, wherein:

Fig. 1 illustrates diagrammatically in plan view partly in section, a part of an aircraft wing embodying the invention.

Fig. 2 is a section on the lines 2—2, Fig. 1, looking in the direction of the arrows.

Figs. 3, 4, 5 illustrate a side elevation, a longitudinal section and a cross-section along the line 11—11 of Fig. 4 respectively of a modified form of a diversion means according to the invention.

Fig. 6 is a plan view of a wing and part of a fuselage of a jet propelled aircraft showing an application of the invention thereto and embodying a modified form of the invention.

Fig. 7 is a section on the line 13—13, Fig. 6.

The drawings are essentially diagrammmatic and the same reference characters are used throughout the figures for the same or equivalent parts.

The form of the invention illustrated in Figs. 1 and 2 of the drawings is applied to an aircraft in which a jet propulsion unit A is mounted in a wing B and consists in disposing in the main jet tube C, a baffle or diaphragm D associated with means (not shown on drawings) whereby it may be gradually introduced into the gas stream or closed thereon to divert its force, the cross-section of the jet tube being suitably shaped to receive the baffle. The combustion gases so diverted are lead by one or more ducts or conduits E, each having an outlet F to the inlet G of a discharge conduit H, the outlet J for the said conduit H pointing in any required direction, for example, forward and/or downward for the purpose of checking the speed of the aircraft or increasing its lift.

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The outlet J of the conduit H is directionally controlled so that the resultant force thereof will act in the plane or in planes parallel to the plane of symmetry of the aircraft, so that the diverted gases may be directed towards the ground and forward or backward as required for increasing the lift at braking or taking off respectively as illustrated in Fig. 2. For this purpose, the conduit H is mounted in bearings K, L, a trunnion M integral with the conduit H resting in the bearing K and the inner end of the conduit H being mounted in the bearing L. In order to rotate the conduit H along its path of movement, a pinion N is secured to the inner end of the conduit H, a suitable means being furnished to actuate the said pinion to effect the required disposition of the conduit H.

The conduit E may be lead straight into the conduit H or as an optional feature as shown in Fig. 1 of the drawings, the inner end G of the conduit H may be splayed to receive the outlet end F of the conduit E, thus introducing an ejector drawing air, for example, from a boundary layer into the chamber G and from there into the conduit H. The conduit H is normally housed within the wing structure, the lower face of which is fitted with doors P which are dropped when it is desired to bring the conduit into position for operative purposes. The outlet J of the conduit may be furnished with a closure Q.

The invention is applicable to all forms of jet propulsion units whether mounted in the aircraft wings or in the fuselage of an aircraft, the ducts or conduits being disposed in the most suitable position in relation to the propulsion unit subject to the inlets being arranged in the discharge conduit and the outlet in such a position as to create a rectionary effort, whether directed in axial opposition to the normal jet flow or at an angle thereto, the resultant force being utilised as a means of control.

Figs. 3, 4, 5 show a modification of the invention in which the jet nozzle C has an elbow joint Q formed of a number of members which are capable of nesting together to form a through conduit (see Fig. 4) or being diverted by concerted or independent operation as shown in Fig. 3 to

give a discharge in the reverse direction or in a direction determined by a path of 180° in a plane or in planes parallel to the plane of symmetry of the aircraft through which the nozzle can be turned.

The elbow joint Q comprises four members Q^1, Q^2, Q^3, Q^4, of which Q^1 and Q^4 are fixed to the jet nozzle elements H and C, respectively, terminating the intermediate members Q^2 and Q^3 to be independently operated to an open position to enable quick recovery of the normal jet flow to a comparatively straight line course. Further, all or one of the members Q^1, Q^2 and Q^3 may be slotted to permit partial flow of the gases to reduce the initial pressure at the outlet of the nozzle and obtain a smooth braking effect when the nozzle is brought into use. In effect the elbow constitutes a valve controlling the gas flow. The jet nozzle conduit may also be reduced to provide a Venturi portion as at Q^2 to which inlets Q^5 are made from any suitable surface of the aircraft.

Figure 5 indicates diagrammatically a method of operating the several parts of the elbow. In this figure Q^1 is fixed to the conduit H and operable therewith, Q^2 is secured to a sleeve Q^7, and Q^3 to a shaft Q^8, the member Q^4 being free of the shaft and secured to the jet nozzle.

Figs. 6 and 7 illustrate an arrangement in which the jet propulsion unit A is mounted in a wing B transversely to the thrust and drag line, the nozzle C having an elbow part C^2 which is mounted in a pivotal bearing M such as described with reference to Fig. 1, the inlet end of the discharge nozzle being mounted for rotation in a gland R. The normal position of the discharge nozzle is as indicated in dotted lines in the Figs 12 and 13, whereas the braking position of the discharge nozzle is indicated in full lines in these two figures. The outlet of the discharge nozzle is fitted with a diffusion cone C^3, this cone may be adjustable, for example, axially slidable, can be rectangular and provided with adjustable louvres.

Broadly speaking, the invention improves the controllability of jet propelled or partially jet propelled aircraft by two methods, one is to decrease the speed at which the machine is airborne, the other is to increase the lift whereby the machine becomes and remains airborne by diverting the normal jet flow to produce two thrust components, one reacting horizontally forward to induce a rearward braking reaction in the machine, the other acting vertically downwards and thereby generating an increased lifting force.

The invention may comprise any number or arrangement of ducts of any suitable cross-section or of variable cross-sectional area, whereby the velocity of the effluent in the conduits may be accelerated or retarded as desired.

Boundary layer tapping is particularly effective when the propulsion unit is running at full speed and is most required when the aircraft is travelling at a comparatively slow speed, for example, at landing; a slow running aircraft and a fast running engine is thus made possible by the deflection of the jet stream.

What I claim and desire to secure by Letters Patent is:

1. Apparatus for controlling the reaction of a propelling jet in a rigid wing aircraft, comprising a jet tube mounted approximately parallel to the line of flight, means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal, a discharge conduit associated with the jet tube adapted for receiving the diverted gases, the discharge outlet of said discharge conduit being selectively movable about an axis in an arc of approximately 180°, in a plane substantially perpendicular to the plane of the wing for directionally controlling the discharge of gases from the conduit to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft.

2. Apparatus according to claim 1, wherein in at least another position of the discharge conduit, a braking and lifting reaction on the aircraft is effected.

3. Apparatus according to claim 1, wherein the discharge end of the discharge conduit is movable in a plane parallel to the plane of symmetry of the aircraft.

4. Apparatus according to claim 1, wherein the means for diverting the flow of at least part of the gases, is a valve.

5. Apparatus according to claim 1, wherein the discharge conduit is mounted for pivotal movement.

6. Apparatus according to claim 1, wherein the discharge conduit is mounted for pivotal movement and comprises an elbow joint formed of a number of members capable of nesting together.

7. Apparatus according to claim 1, wherein the discharge conduit is mounted within an aircraft wing structure and the outlet of said conduit, in controlled operative position, is at the under side of the wing structure.

8. Apparatus according to claim 1, wherein the reaction generated by the diversion of the jet passes through a point between the leading and trailing edges of the wing.

AUBREY DOUGLAS

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The following references are of record in the file of this patent:

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1,813,189	Moore	July 7, 1931
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Number	Country	Date
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A-73

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June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 1

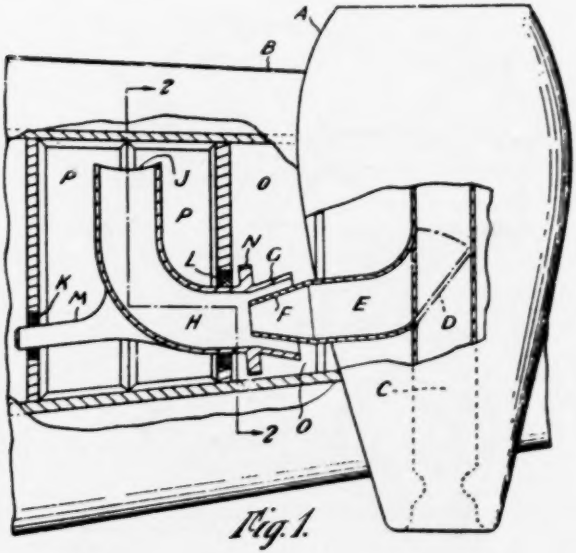

Fig. 1.

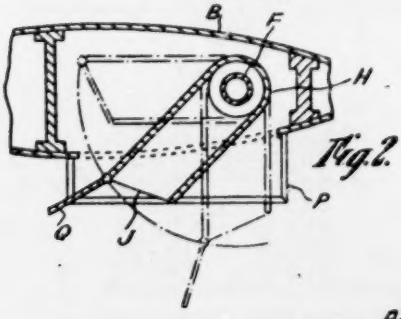

Fig. 2.

Aubrey Douglas

By Wm. Myers Manley

Atty's

June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 2

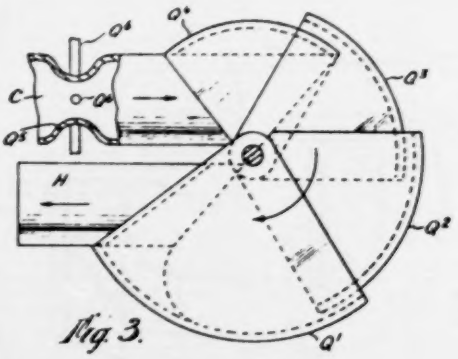

Fig. 3.

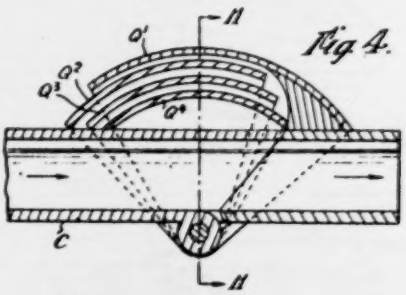

Fig. 4.

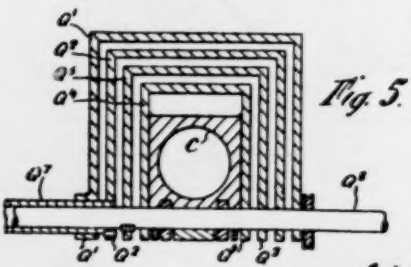

Fig. 5.

Audrey Douglas

By Thew, Myers & Manley

Atty's

A-75

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June 17, 1952 A. DOUGLAS 2,601,104

JET PROPULSION AND CONTROL MEANS THEREFOR

Filed Sept. 10, 1946 3 Sheets-Sheet 3

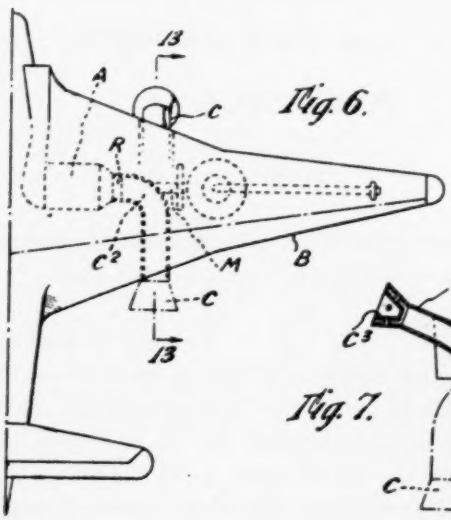


Fig. 6.

Fig. 7.

Andrew Douglas
By Fraser, Myers & Manley
Attys

U.S. GOVERNMENT PRINTING OFFICE: 1978

APPENDIX G

PLAINTIFF'S EXHIBIT 5

VICKERS-ARMSTRONGS LIMITED
(AIRCRAFT SECTION)
SUPERMARINE WORKS, SOUTHAMPTON

SPECIFICATION.

No. 512.

PROPOSED EXPERIMENTAL DEFLECTED-JET INSTALLATION IN NAVAL "ATTACKER".

Introduction.

In order to land-on Naval aircraft as slowly and accurately as possible it has been the practice with piston-engined propeller driven aircraft to employ a considerable amount of engine when making the approach. The additional lift obtained due to the passage of the airscrew slipstream across the wings reduces the safe minimum landing speed appreciably. Further, with throttle closed the airscrew provides considerable air drag and thrust is, therefore, readily convertible to drag by mere operation of the throttle control. Finally, when the pilot receives the 'cut' signal from the batsman and closes the throttle, lift is immediately lost and the aircraft has considerably less tendency to float, bounce or balloon than would otherwise be the case. The combination of these features provides extremely accurate control of glide path and turns engagement with the ship's arresting wires from a somewhat precarious operation into a practical everyday proposition.

In the event of a baulked landing the engine is already running at something like half throttle and responds quickly

on the "wave-off" signal. This quality can be extremely valuable when the "wave-off" signal is given late and the pilot is expecting the 'cut'.

On jet-engined aircraft, designers have recently been much exercised in reconciling high climb and top speed requirements with reasonable landing speeds. Considerable thought has also been given to ways and means of replacing the control of glide path provided by the slip lift and drag which has been so valuable in the normal airscrew-driven aeroplane. Again, in order to ensure rapid opening-up to maximum thrust in the event of a baulked landing, it has been thought desirable to effect the approach at considerable R.P.M.

The basis of the present proposal is that if the jet were deflected about 60° downwards at or about the C.G. of aircraft by a flap in the jet pipe, then the approach would be made at higher R.P.M. and the resultant lift due to the deflected jet would provide the jet aircraft with approach characteristics similar to those obtaining with propeller-driven types. The improvements obtained in glide path control, although valuable, is secondary to reduction in approach speed. The effective weight of the aeroplane is reduced very considerably by the vertical component of deflected thrust, which results in 15 to 20 per cent reduction in approach speeds, depending on the thrust/weight ratio of the particular aircraft.

Application.

Although several jet-powered aircraft have already been landed-on with complete success without the assistance of a downwardly deflected jet as a means of reducing approach speed, nevertheless their entry speed into the wires has been a matter of some concern and their requirements are only just met by existing arresting equipment.

The next stage in fighter development is the back-swept wing which aims at considerable improvement in top-speed performance. Up to the present, however, the possibility of operation of back-swept wing aeroplanes by the Navy has seemed remote due to the low maximum lift coefficient obtainable with wings of that form and the consequent rise in entry speed into the wires.

It seems to us that the jet deflection provides just the answer to this problem. With jet deflection the back-swept wing aeroplane may be landed-on at a speed less than that at present associated with straight-wing aeroplanes of the same type. We feel, however, that the initial experiment requires a vehicle the characteristics of which are well known and well understood thus providing a reliable yard-stick for measurement of the anticipated gains. For this reason we suggest that the scheme be applied in the first place to a Naval "Attacker" with provision for a subsequent switch to "Swift" back-swept wings when the value of the basic idea has been proved by trials.

Layout.

The attached General Arrangement and Fuselage Layout drawings indicate how the scheme works out. It will be observed at once that the engine has been moved forward very considerably—about 10 feet in fact. This is due to a desire to avoid any pitching moments of the deflected jet about the C.G. of aircraft. The nose of the aircraft has been lengthened about 3 feet.

Fuel is carried approximately at the C.G. of aircraft.

The aircraft in its new form ceases to require nose ballast and tends in fact to become somewhat nose heavy. We have taken advantage of this fact to introduce a re-heat tail pipe which provides improved performance in these circumstances at no weight cost. Weight and space provision has accordingly been made, but it has not, however,

been assumed that re-heat will be applied to the initial experiment.

Weight and Balance.

Arrangements have been made to balance the aeroplane at 37.5% S.M.C. to meet the requirements of the longer fuselage nose and, with 300 gallons of fuel, the all-up weight of the aircraft in this condition would be 12,000 lb.

A detailed weight list is appended.

Effect on Performance.

This proposal results in a reduction of 16 knots in the approach speed, defined as 1.15 Vs.

In the approach the jet is deflected to an effective angle of 77° and the engine speed is set so as to give 3,500 lb. of thrust. It is estimated that the approach path will be 5° under these conditions.

In the baulked landing case the adjustable nozzle is moved to give an effective deflected angle of 60°. At the same time as the angle is reduced the throttle is opened so that the engine gives its maximum thrust of 5,000 lb. In this condition the rate of climb is 550 ft/minute before the landing flaps are adjusted to the take-off position.

Structure.

The experiment would require a completely new fuselage. The "Attacker" wings or alternatively the "Swift" wings would attach to the fuselage without alterations to either type of wing. The fuselage diameter is increased 3 ins. to cover the further forward position of engine.

The tail unit roots might need detail modification to suit the lines of the fuselage tail modified for the re-heat jet pipe.

Deflector Unit.

The deflector unit is attached directly to the after end of the engine exhaust cone. In normal flight the deflector flap forms a sort of trap door in the floor of the unit, and is flush on the inside. In the approach condition the flap is raised and uncovers the passage to the deflected duct, at the same time closing the normal straight-through passage. The flap would be power-operated.

The design for the deflector unit presents certain problems which have not previously been met. Insofar as the engine itself is concerned it is not thought that any particular difficulty arises, but there are clearly considerable mechanical, metallurgical and cooling problems. A design for the valve box has been prepared and the matter has been discussed briefly with the engine manufacturers who have had to deal in the past with similar features in connection with variable nozzle orifices and jet spoilers. We do not, therefore, anticipate any serious difficulty in the design of the valve unit, but it obviously requires early and expert attention.

Re-Heat.

Re-heat is not, of course, an essential part of this experiment, but it is clear that if the standard power plant only is to be employed the speed and climb performance of the modified aircraft might be inferior to that of the original.

If re-heat is employed the performance of the aeroplane is improved all round and in our opinion provision for it is to be recommended. As already mentioned, we would not suggest its inclusion initially.

The tail plane front spar frame needs to be enlarged to take the larger jet pipe but presents no serious difficulty.

Fuel.

It should be observed that the position of the deflected jet outlet precludes the carriage of overload fuel in a ventral drop tank.

Conversion to "Swift".

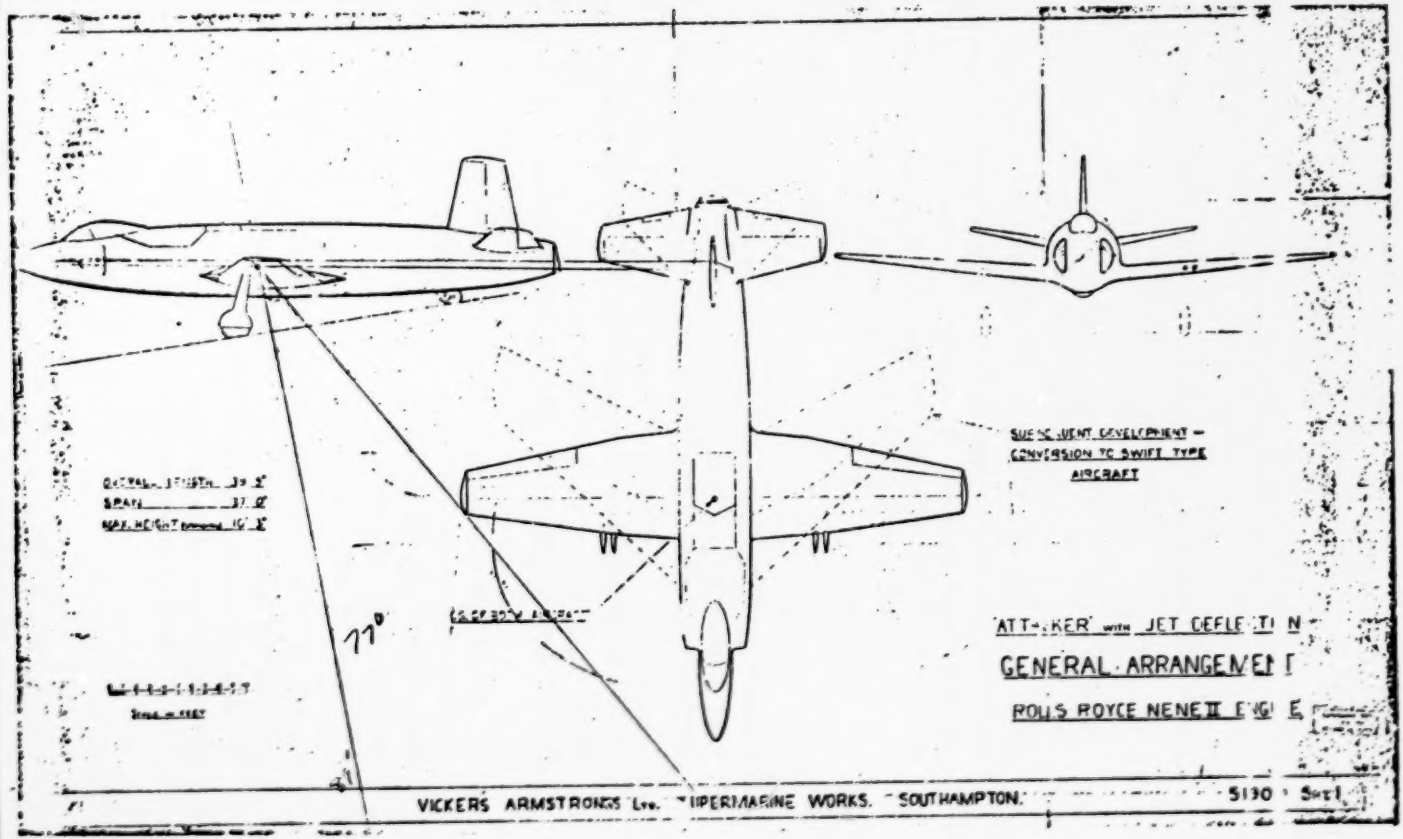
The General Arrangement drawing shows the relation between the "Attacker" and "Swift" wings on the new fuselage. It will be seen that some modification to spar frames will be necessary to effect the change. Broadly speaking the modifications are less than those involved in converting the present "Attacker" to the present "Swift" because provision for the change would be made as far as possible at the outset.

VICKERS-ARMSTRONGS LIMITED

WEIGHT LIST

	Component		*Weight* lb	*Percentage A.U.W.*
STRUCTURE:—				
A	Mainplane, including centre section		1,684	14.0
B	Fuselage		1,372	11.4
C	Tail unit		284	2.4
D	Landing gear		512	4.3
E	Flying controls		186	1.5
TOTAL STRUCTURE			4,038	33.6
POWER PLANT:—				
G	Engine, dry		1,786	14.9
	Jet deflector gear		350	2.9
	Jet pipe extension		110	0.9
	After-burner and nozzle		300	2.5
H	Engine Mounting		23	0.2
J'	Oil in engine		14	0.1
K	Power plant accessories		141	1.2
TOTAL POWER PLANT			2,724	22.7
FUEL SUPPLY:—				
M	Permanent fuel tanks		297	2.5
N	Fuel system for engine		140	1.2
N'	Fuel system for after-burner		100	0.8
TOTAL FUEL SUPPLY			537	4.5
POWER SERVICES:—				
R	Hydraulic services		165	1.4
S	Pneumatic services		34	0.3
T	Electric services		190	1.6
TOTAL POWER SERVICES			389	3.3
FIXED LOAD:—				
U	Fixed protection, total, comprising:—		104	0.9
	De-icing	6	—	—
	Protective windscreen	78	—	—
	Fire-fighting	20	—	—
V	Fixed armament		89	0.7
W	Fixed equipment, total, comprising:—		405	3.4
	Furnishings	150	—	—
	Heating systems	7	—	—
	Pressurizing	36	—	—
	Oxygen	32	—	—
	Other equipment	180	—	—
TOTAL FIXED LOAD			598	5.0
Unaccounted and contingency			176	1.4
TARE WEIGHT			8,462	70.5

Component		*Weight lb*	*Percentage A.U.W.*
REMOVABLE LOAD:—			
A′	Removable armament	823	6.8
B′	Removable equipment	85	0.7
C′	Pilot and parachute	200	1.7
	Ballast	—	—
TOTAL REMOVABLE LOAD		1,108	9.2
BASIC OPERATIONALLY-EQUIPPED WEIGHT		9,570	79.7
DISPOSABLE LOAD:—			
D′	Fuel: 300 gall.	2,430	20.3
TOTAL DISPOSABLE LOAD		2,430	20.3
NORMAL ALL-UP WEIGHT		12,000	100


SUBSEQUENT DEVELOPMENT –
CONVERSION TO SWIFT TYPE
AIRCRAFT
77°
ATTACKER with JET DEFLECTION
GENERAL ARRANGEMENT
ROLLS ROYCE NENE II ENGINE
VICKERS ARMSTRONGS Ltd. SUPERMARINE WORKS. SOUTHAMPTON.
5130 Sht 1

APPENDIX H

PLAINTIFF'S EXHIBIT 34

REPORT ON JET DEFLECTING PROPOSALS

By MR. A. DOUGLAS

Gritton Memo
6/INV/57/5

Introduction

As far as it is known Mr. Douglas has made no claim against the Crown in respect of any jet deflecting proposals or vertical take off machines. It was considered that the matter should be investigated as a potential claim in view of experiments being carried out by the Crown.

PATENTS OF MR. DOUGLAS

Patent No. 643969

This patent is for "Improvements in Jet Propulsion of Aircraft and Control means therefor" — Application Date October 15th, 1945. Date of Filing Complete Specifications August 27th 1946. The Patent is in force.

The main claim is difficult to construe because an expression "and/or" is used indicating two possibilities. The claim covers apparatus for controlling the reaction of a jet propelled air craft by

(1)(a) baffling)
(b) or reducing) the effective area of the jet tube *and* diverting partially or wholly the combustion gases in a direction other than the normal direction of flow.

(2)(a) baffling)
(b) or reducing) the effective area of the jet tube *or* diverting partially or wholly the combustion gases in a direction other than the normal direction of flow.

The apparatus consists of:—

(3) a baffle or diaphragm with means for gradually introducing it into the gas stream to divert or baffle the bases to an outlet.

(4) a discharge conduit for receiving the diverted or baffled gases which may be part of the jet tube and capable of movement to direct the diverted gases whereby a braking and/or lifting reaction is obtainable.

The discharge conduit when it forms part of the jet tube is arranged to be moved from that position to a position where it can direct the gases to produce a braking and/or lifting reaction.

The discharge conduit when it does not form part of the jet tube is arranged to one side or below the jet tube and a baffle or diaphragm is placed across the jet tube to direct the gases to a branch outlet from the jet tube leading to the discharge conduit which is arranged with its outlet pointing in the direction required for example forward and/or downward for the purpose of checking the speed of the aircraft and increasing its lift.

Patent No. 644610

This patent is directed to a downwardly directed lifting jet or a forwardly directed braking jet for boundary layer suction. No anticipation of this is known, but its novelty has not been investigated because it does not appear to be used.

Prior Art

The following citations brought forward by the Patent Office under Section 7 of the Patents and Designs Act are as follows:

G.B. No. 523468	G.B. No. 237717
402429	191868
235630	118123
157281	13312/11
472850	

Those brought forward under Section 8 of the Patents and Designs Act are as follows:—

G.B. No. 600075 2164/46
597261 1492/46
2257/46 the last three as open to inspection under Section 91

The following specifications were also considered:—

G.B. No. 14631/05 and Gas Turbine and Jet Propulsion for Aircraft by G. Geoffrey Smith.
U.S. No. 1714917

U.S. No. 2024274
G.B. No. 347206

Novelty of Patent No. 643969

Claim 1 would appear to be completely anticipated by what is shown in Figure 6 of the prior Patent Specification No. 191868. Although this earlier patent is concerned mainly with hydraulic jet propulsion of ships, it is stated clearly that the invention is applicable to jet propelled aircraft. The arrangement according to Figure 6 if mounted in a jet aircraft would seem to fall within what is defined by Claim 1 of Patent No. 693969. The apparatus would certainly reduce the effective area of the jet tube as Figure 6(b) or baffle the tube as in Figure 6(a); it can also divert the stream partially as shown in Figure 6(b) or wholly as shown in Figures 6(a) and 6(c). The sectors b1 and b2 are certainly baffles or diaphragms which can be moved gradually across the path of the jet stream in the manner of D, or Q2 and Q3 of Douglas and so fall within whatever meaning is assigned to the claim. It can be said that the diverted stream has an outlet into a "discharge conduit" shown at b2 in Figure 6(c) and it can be said that this discharge conduit shown at b2 can be moved from the position shown in Figure 6(b) to that shown in Figure 6(c) to direct the diverted stream. Similarly the arrangement shown in Fig-

ures 3-7 of patent specification No. 14631/05 disclose the essence of Claim 1 of the Douglas patent. It is considered that b can be regarded as a jet tube and this can have its effective area reduced as shown in Figure 5 or it can be baffled as in Figures 6 and 7. The element M pivoted at i are baffles or diaphragms which may be gradually moved across the jet stream. The diverted stream has an outlet into "discharge conduits" shown by the reference m: these are capable of movement to direct the diverted stream, as may be seen by comparing Figures 6 and 7. The conduits n are part of the jet tube but it does not matter whether they are or not. The "baffles" are of course, the boundary walls of the jet tube and those may be perhaps some slight doubt as to whether claim 1 of Douglas is to be read as excluding this or not.

General State of the Art Prior to Mr. Douglas Patents

Douglas is by no means the first to propose a rearwardly directed jet propulsion pipe having a downwardly directed nossle for providing lift and valves in the pipes movable across the jet stream to divert the gases from one nossle to the other. Such combination is disclosed in Ljungstroms Patent No. 472350 of 1939 which is also shown in all the four editions of Geoffrey Smith's book Gas Turbines and Jet Propulsion, Figure 17 page 27. An earlier disclosure of a similar nature is Martin's U.S. specification No. 1714517 which shown a rearwardly directed jet pipe with a downwardly directed branch nossle and butterfly valves in each for controlling and diverting the flowing gases.

A downward jet deflector is shown in Campini's G.B. specifications Nos. 406713 and 403634 and U.S. specification No. 2024274. The Caproni-Campini aircraft is not known to have had such a downward jet deflector but it is interesting that it included in the rear nossle of a deflector which could direct the jet rearwardly or slightly sideways or

slightly down. The deflector nossle is shown in Figure 37 on page 51 of Geoffrey Smith's book.

A report No. Acro 2007 dated January 1945 "Wind Tunnel Tests of Oblique Jet Units" discloses that some tests had been carried out on a model aircraft with jet propulsion nossles ejecting obliquely from the sides of a fuselage to investigate surface heating and loss of thrust due to interference. It is of interest to know that one of the series of tests was with the nossle ejecting from the bottom of the fuselage.

Alleged Use of the Invention

Since jet deflection is not used in the "Flying bedstead" it is outside the scope of the claims of the Douglas patent.

A Meteor aircraft was provided with downwardly directed branches in each of its rearwardly directed propulsion pipe sand pivoted baffles were arranged on the downstream corners of the junction of the pipes and branches to be introduced into the gas stream and baffle the propulsive pipe to divert the bases through the branch.

It is understood that the branch was fixed and incapable of any movement to direct the gases discharged from the branch. This means that what was used by the Ministry is clearly outside the scope of the Patent No. 643969.

The Origin of the Ministry Development

It would seem from the documents to hand that Rolls Royce were interested in vertical take off and downwardly directed jets from 1944 onward primarily with the idea of using small engines directing their thrust downward. The "Flying Bedstead" was the first test vehicle for Rolls Royce development.

On the 10th August 1948, Mr. Smith of Vickers-Armstrong sent a copy of their Specification No. 512 to Mr. Scott-Hall. This specification discloses a Naval "At-

tacker" aircraft with a downwardly directed branch pipe from the rearwardly direction propulsion pipe. The branch being arranged so that the reaction from the thrust passes through the centre of gravity of the aircraft. The letter accompanying the Specification No. 512 states that the idea on which the specification is based is covered by a patent No. 26967/45 of a Mr. A. Douglas of Bristol. Rolls Royce were approached on the engine side of the deflector jet proposals. The Royal Aircraft Establishment were asked to comment on the proposals and gave their views for and against and D. Eng. R.D. also gave their views.

D. Eng. R.D. stated that they would like to see the scheme tried out and D.M.A.R.D. agreed but thought that facilities in the Ministry were not adequate and Rolls Royce were too busy. The National Gas Turbine Establishment were approached but stated were unable to take it on as similar work on thrust spoilers had been deleted from their research programme. Also since there were no fundamental research problems in the development, industry should do the development work.

Mr. Douglas had an interview in January 1951 at the Ministry of Supply and left some documents including letters from Vickers Armstrong in relation to his invention and to the "Attacker" scheme. (i.e. specification No. 512). He wished to know what was happening to the proposed development. Mr. Douglas approached the Ministry again asking what was happening to the development.

Mr. Douglas had an interview with Mr. P. A. Shaw, A.R.D., Dr. Remfry Eng. R.D.3 and Mr. Ewins T.P.A.3 on 3rd August 1954 and was told that the Westland Meteor experiment was in hand and that there were several engine firms with proposals for yet spoiling. Both the Westland Meteor experiment and the jet spoiling experiments Mr. Douglas was told had a bearing on his invention.

From minute 8 it would appear the Mr. Douglas has invented something like £10,000 in his patents i.e. two British patents Nos. 643969 and 644011 and corresponding Foreign patents in eleven countries.

Conclusions

(1) Mr. Douglas has two patents Nos. 643969 and 644011.

(2) His patent No. 643969 is the patent which Vickers Armstrong acknowledges as being concerned in the Attacker jet deflector scheme specification No. 512.

(3) Patent No. 643969 is in force (present date 23.1.57).

(4) The patent is directed to apparatus for controlling the reaction of a jet propelled aircraft by:—

(1)(a) baffling or (b) reducing) the effective area of the jet tube *and* diverting partially or wholly the combustion gases in a direction other than the normal direction of flow.

(2)(a) baffling or (b) reducing) the effective area of the jet tube *or* diverting partially or wholly the combustion gases in a direction other than the normal flow.

(3) a baffle or diaphragm with means for gradually introducing it into the gas stream to baffle or divert the gases to an outlet.

(4) a discharge conduit for receiving the baffled or diverted gases which may be part of the jet tube and *capable of movement to direct the diverted gases* whereby a braking and/or lifting reaction is obtained.

(5) The validity of the Douglas patent is doubtful in view of the following:—

G.B. Patent Specification No. 191662
G.B. " " " 14631/05
U.S. " " " 1714917
G.B. " " " 472850

Geoffrey Smith's Book Gas turbines and Jet propulsion particularly Figue 17 page 27.

(6) The Ministry of Supply's Westland Meteor has a baffle which is introduced into the gas stream to divert partially or wholly the combustion gases in a direction other than the normal direction of flow to a discharge conduit which is *incapable* of movement from the direction in which it is set.

(7) The Westland Meteor is outside the scope of the Douglas patent.

(8) Any jet propelled aircraft that may be built under Contract and has a branch with a baffle for diverting the combustion gases to a discharge conduit which is capable of movement to give

(1) a braking and lifting force,
(2) a braking or lifting force,

must be studied carefully as the Ministry has been made aware of the Douglas patent by Douglas and by Vickers Armstrong and although the patent is of doubtful validity sympathetic consideration should be given to any possible use.

APPENDIX I

No. 197-70

AUBREY E. DOUGLAS,
Plaintiff,
v.
THE UNITED STATES,
Defendant.

TRANSCRIPT PAGES CITED IN PLAINTIFF'S BRIEFS

DENNING
Direct Examination

* * * *

[118] The Commissioner: Let us strike the question and answer and rephrase it. That's the one you want anyway, Mr. Townsend. At least that's the one I want to hear.

By Mr. Townsend:

Q. Mr. Denning, has anyone to your knowledge, anywhere in the world, ever constructed an aircraft as shown in the figures and drawings of the Douglas patent —

The Commissioner: Substantially as shown. Let us put it that way, not necessarily identical, but substantially as shown?

The Witness: To the best of my knowledge, nobody has, but I cannot be sure I am exhaustive in that answer.

By Mr. Townsend:

Q. To the best of your knowledge, having been the chief engineer in the company that has done the most work in the world on the V/STOL aircraft, you have never heard of any instance where anyone has ever constructed —

The Commissioner: He has already answered the question, Mr. Townsend. You are gilding the lily.

By Mr. Townsend:

Q. In your opinion, would it be possible, using the drawings of Mr. Douglas, to construct an aircraft capable of V/STOL operation?

[119] The Commissioner: Wait a minute. Let us say using the drawings and specifications, the whole teaching.

The Witness: I think in principle one might construct an airplane around figure 6, but with the proviso that one would have to solve the mechanical problems by a different way than shown by Mr. Douglas.

Mr. Townsend: Your Honor, I would like to put that into the proper time perspective, because the witness is testifying I think from the standpoint of having done all the work on the Pegasus engine.

I think we have to go back to the time that Mr. Douglas made his invention or when he filed in the United States whether there was technology available at that time to construct, as far as Mr. Denning is concerned, an aircraft capable of V/STOL operation.

Mr. Russell: I would like to strenuously object to Mr. Townsend's speech attempting to overcome by oratory the effect of an answer he didn't want. The answer was excellent and it should stand.

Mr. Townsend: Your Honor, I submit that we should be able to explain what the witness really meant.

Mr. Russell: You are explaining what he is saying.

The Commissioner: I think the witness' answer is [120] clear. If you want to put a time frame on things, I think it is appropriate, but let us not try to change the witness' answer. You can time frame this in any way you desire.

The Witness: It would not be a very good airplane I don't think. And as I said, you would have to modify, as far as the mechanical design is concerned.

By Mr. Townsend:

Q. Let us go back in the time frame and refer back to your answer. Would it have been possible in your opinion to construct an airplane capable of V/STOL operation using the teachings of the Douglas drawings and specifications in 1946 or '45? A. A V/STOL airplane?

Q. Yes, sir. A. The weights of engines in 1945 and '46 the weight for a given amount of thrust was very high, and I think it would have been virtually impossible in 1946 to have made an airplane which would have had a reasonable powerplant weight which would have allowed you to take off vertically. It was only the advent of very high thrust-weight ratios, very lightweight engines which enabled us to achieve vertical takeoff.

Q. When you say advent, you mean the considerable effort, 2.5 million engineering man hours — [121] A. That is right.

Q. — working with the nozzle design and powerplant design being designed to be compatible with one another that you were able to actually first achieve vertical takeoff and landing by vectoring the nozzles? A. Yes. Perhaps I misunderstood. I was assuming I was being asked the question was figure 6 a viable way of producing a vertical takeoff or V/STOL airplane. I think you could make one, but it would depend on the achievement of the technology we have just talked about.

By Mr. Townsend:

Q. Would you consider the nozzle structure used in the Pegasus engine and the Kestrel aircraft to be an obvious advance over the structure shown in the Douglas patent? A. Yes. By "obvious" you mean that it took a large amount of design effort and it was evolved after a lot of thought?

Q. Let me rephrase the question. Perhaps you didn't understand it.

Could the reporter read the question back, please.

(Whereupon, the reporter read the record, as requested.)

The Witness: Yes, I think it is an obvious . . .

• • •

DENNING

Cross-Examination

[131] XQ. . . . the nozzle is virtually on the — or close to the center of gravity of the plane; is it not? A. Yes.

XQ. I call your attention to exhibit 3 which was offered here today and ask you whether you can state whether the Wibault thrust elements for lift augmentation actually are on the center of gravity and whether they could be as they change their direction? A. They would not be completely on the center of gravity at all times as they rotated unless — I think it would not be possible to achieve that.

XQ. That is one of the major drawbacks of Wibault, isn't it, that you haven't mentioned earlier today? A. Yes. I don't know whether we ever went into it in that sort of detail at that point in time.

XQ. The Wibault device actually would not be suitable for the reason that it is not pivoting with its thrust going through the center of gravity? A. It would certainly require an additional balancing jet.

XQ. Whereas in the Douglas figure 6 you see the jet rotating on the center of gravity axis, or close to it? A. Yes.

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[149] XQ. Isn't it a fact that when you started out with Kestrel the design requirements were for a light fighter and then as the thing progressed various people kept piling more and more onto it. Therefore, the original idea of just building a light fighter went by the board and you eventually had to project a much heavier effort? A. I can recall talking to the designer, the late Sir Sidney Kamp.

And his original idea was an airplane which would carry a camera for 100 miles. And that was all.

XQ. Now, the Kestrel would have been very adequate for such purposes, wouldn't it? A. Yes it would. It probably would have, yes. But whether the RAF would have regarded that as an operational airplane, I do not know.

* * *

LANCASTER

Direct Examination

[250] pilot would takeoff with the structure shown in Exhibits 6 and 7 — Figure 6 and 1 of Exhibit 4? A. Well, if you had enough thrust, which means you had more thrust than the weight of the aircraft, you could take off vertically, if we had that jet nozzle C, straight downward, and if he could control the aircraft.

[251] Q. I'd like you to outline for the Court an illustration of what you think that the pilot would do with this disclosure of the plane of this sort. Just give a kind of a typical illustration. A. If he had a long runway, most pilots would take off right down the runway. If you had a short runway, he would turn this nozzle downward.

Q. And rearward at the same time? A. Well, depends on how short the runway is. If you have to take off the roof of a building, you would probably turn it directly downward and go off vertically.

They are going to leave — a pilot is going to leave some leeway at the end of a runway so it is going to depend upon the circumstances.

The whole idea here, as I see the situation — this is the first time — and by the way, back in 1946, we didn't have good enough engines that you could take a full operative plane off in this direction, I don't believe. But you could have taken most — you could have taken airplanes off in a vertical direction because then we had had

engines that put out thrust at least three pounds to the weight; and if you could make the airplane and the pilot and everything else the other two-thirds, a guy could take off vertically by just deflecting the jet in that direction.

[252] Q. Even with ordinary engines of that time, it would have been all right for a STOL —

Mr. Russell: Your Honor, that means short takeoff.

The Witness: Yes. Yes, it would help.

By Mr. Russell:

Q. What would be the mode — how would he continue to fly — and I call your attention to column 3, line 50, in which he refers to the aircraft remaining airborne. A. 53, you say?

Q. Column 3, line 50. A. Line 50?

Q. You see where it says remaining airborne? A. Sure.

Q. How would he remain airborne in slow flight with the device shown in Figure 6 and 7? A. Well, he could keep his engine revved up as high as he wants, provided the jet thrust wasn't too great and slow his airplane down by two ways: He could turn it forward and see that it slowed down, was a braking effect; or he could have it partially rearward. Note if he had it perpendicular down, had the r.p.m. up, the thrust was greater than the weight, he'd continue to rise. He has to continue to deflect it forward or backward.

[253] Now what he would do would depend upon what he is doing.

Q. He could dethrottle, too? A. Yes, he could throttle.

If — as I say, I think there are two things here. One advantage is that he could keep the r.p.m. up; and the other, he could take off vertically. Those are the two things that I think were important when this came along.

Q. If he came in for a fast landing — A. If he came in for a fast landing —

Q. If he were coming in fast and wanted to slow down, what would he do? A. Turn it forward and brake it.

Q. In midair? A. He could.

Q. Now — A. Midair, I don't know what you mean by midair, but in air.

Q. Airborne. A. All right, airborne.

Q. If you will look at column 2 — we are now referring to Exhibit 4, line 11, and for the next few lines, would you explain to the Court what is meant by ". . . the plane of symmetry of the aircraft? [254] A. Well, an aircraft is something like a human being. If you take a plane down the middle, there is a right and left ventricle and right and left leg. The plane is built somewhat the same. We have a right and left. It is a plane of symmetry that normally goes through the fusilage in a vertical direction.

Q. So that the disclosure of Figure 6 and 7 is intended to convey the idea of the partition of the same elements on the opposite side of the plane? A. Oh, yes, I don't think there is any question about that.

And on —

Q. Could you now refer to column 3, lines 31 and following for a few lines there, where it is mentioned that the propulsion unit is mounted in the wing, B, transversely to the thrust and drag line? A. Well, transverse would mean perpendicular if we are talking about lines. We all know that you don't get dragged until you start something moving; so we have first your thrust and then when you start moving through the air, then you get a drag that's negative to it. So really your drag line is always tangent to the flight path, whatever that may be.

Now I didn't say where it was. You have a result

* * *

[262] resultant force being utilized as a means of control."

And I also call your attention to column 3, lines 57, 58, 59, 60, 61, where it says, "The invention may comprise any number or arrangement of ducts of any suitable cross-section of variable cross-sectional area, whereby the velocity of the effluent in the conduits may be accelerated or retarded as desired."

I ask you to state for the Court what these words that I have called your attention to mean to you, with respect to controlling the aircraft. A. Let's come back to the first here. The second, I think, is clear. What was the first line?

Q. The reactionary effort brought about — A. The line, line.

Q. Column 2, lines 46 to 49. A. "Whether directed in axial opposition or at an angle angle thereto."

Q. "The resultant force being utilized as a means of control."

And then together with the other part where it talks about variable cross-section — A. The reason — the reason I wanted to go carefully over that, I can't conceive of how we can shut the jet, the main jet off, of the aircraft. This has been one of the [263] problems I alluded to earlier by keeping r.p.m. and cutting it off; whereas the second part over here, these would have to be auxiliary ducts which I do not see in his drawing, in order to — but apparently — apparently he was aware of it. Now you can control the aircraft to a certain extent by moving this back and forward, but that might not eliminate your pitching movements that you would have or even your roll movements in case one engine did not synchronize with the other.

So —

Q. What about the variable effluent in the lines I called your attention to in column 3? A. On 55 it is comprised of any number of arrangements of ducts. I am saying

these ducts here, if you are going to vary the cross-sectional area and so on — or — "whereby the velocity of the effluent" can be accelerated or related as desired. There would have to be other ducts other than those I see in the drawing on page — in Figure 6.

Q. Well — A. He describes something there that I don't see in the drawings, is all I am saying.

Q. Which would be possibly — A. Which would be apparently for control.

• • •

[308] By Mr. Russell:

Q. Professor, do you agree that it would have been — that there would have been insuperable difficulties in building an engine in 1946, for instance, to meet the requirements of the patent in suit which is Exhibit 4? A. I don't think there would have been. I don't believe, though, the patent refers to building a whole engine. I think that — at least as I interpret it — this is a matter of the nozzle aspect and any associated controls that are related to it.

Q. Do you have an opinion as to the — the practicality of that as of 1946 or '47? A. Well, in 19 — let's see, we started out in 19 — beginning to work on these things about 1940 in this country, real heavy. So by '46 we had a lot of the state of the art and I am saying that I don't see anything that's — no, I think we could have done it. It's kind of like going to the moon. It took ten years to go to the moon. I worked with NASA.

So it — we couldn't have done it overnight. I didn't see any insurmountable difficulty.

• • •

[312] they designed a lot of lift engines that were put right in the wing. They were cheap, lightweight engines that were only going to be used a short time for lift. Some of these aircraft here had as many as six of those in them. It was all experimental. I would say that all of

these aircraft were on this basic circle. There are thirteen in this particular circle. During this state of the art, they were mainly considered.

To me, the most intriguing one of the whole situation was the Pegasus type engine because it seemed to me like it met all the difficulties that we had had before, possibly going vertically; much better possibility of control. It eliminated what I thought was more complicated, the rotation of the wings and particularly, if you have propellers on there, one of the biggest problems is the "P" forces when you start rotating in a direction different from the direction of flight.

So the Pegasus one seemed to me like, as I say, a step forward in a state of the art.

So far as I can tell, it is the same principle as I wrote in my letter, as I say in response to this student that asked me—former student at Penn State—that the principle employed there is exactly the principle employed in the Douglas patent.

Q. Meaning Exhibit 4?

* * *

[393] A. No, this is—as I understand the drawing, he had flaps that went all the way around so it was a symmetrical situation for braking somewhat like the clam shells that we have. It was after the duct of the propellers, not at the end of the jet.

Q. The clam shells—when you said—you didn't complete the sentence on the clam shells? A. Similar to what we have. Clam shells thrust reversals on aircraft.

Q. In current use today? When you say what we have? A. They were in use.

Q. The record won't show what "we have" means. A. Okay. That we have had. I will put it in the past. Have had on aircraft. As far as I know, they are on today.

Q. Okay.

Would you now turn to the Harris patent, Exhibit 25?

Mr. Russell: Your Honor, that's Exhibit 25, Defendant's.

The Witness: You want me to comment on it?

By Mr. Russell:

Q. Please comment on the Harris patent. A. That is one that seems to me is very confusing. According to my notes here—well, first, let me say what it is. He has a centrifugal compressor powered by a internal combustion [394] engine and then he has some burning in the nozzle there and around it he has a large duct around the exits of the jets from the centrifugal compressor after the burning.

He expects to get augmentation. Well, this is fine. You can get augmentation there. Whether you need the ducts as large as the drawing indicates or not, I would question. But then he goes on to say that it can be—these can be rotated up and down and it's inconceivable to me that you could rotate those very far up and down without rotating the whole engine.

Again, eyeball drawing may be wrong, but I would say if he rotated more than 20 degrees, that the inside duct would be in contact with the external duct, this duct in contact with that, only we have a circle here, (indicating.)

This would destroy to a large extent the punching power of the ejector. On the other hand, it would still work, but surely this would not be a large angle of deflection. Yet the patent says it may be rotated up and down to give plus or minus lift.

Q. Excuse me, Professor.

Would you turn to page 1 of the Harris patent? A. Yes, sir.

Q. And read the third paragraph, please? A. "The chief objective of the present invention is to avoid expansion of the gaseous stream on entering the discharging [395] tube as it is found with the stream and expanding produces

eddy currents adjacent to the nozzles from which the stream issues and thereby prevents or hinders the entry of air into the discharging tubes thus reducing the efficiency of the motor."

Q. Therefore, Professor, I would like you to address yourself to the question of eddy currents which would be involved in pivoting the tube, K, apart from pivoting the whole engine. A. Well, I thought I addressed myself to that. I felt there would be more such eddy currents. That's a swirling of gas and any time—you have energy in the gas, and what we want is to direct the energy in one direction. Any time you have it going around like this, this is lost energy, (indicating.)

Q. If he pivoted the tube, K, independently of the engine, he would increase his eddy current?

I guess you said that. I'm sorry. A. Well, he would if—beyond a small tolerance. I suppose you could move it slightly but not appreciably.

This one is a little different than the others in that you do have hot gases or may have hot gasses there. If I understand it, you can have burning in L, if I haven't misread it. So in that sense you have a hot gas, it's nearer the patent in question than the others we have been talking about, or may have a hot gas.

* * *

LANCASTER

Cross-Examination

[407] We had reverse props, of course, which is a thrust reversal situation, but I take it you are talking about jets?

XQ. Yes, sir.

Was the concept of thrust reversal in the jet engine known as of 1946, through? A. The concept?

XQ. Yes, sir. A. Well, it is in some of these patents here, the concept.

I mean, we read—went over two or three of those this morning and I'll have to check the dates here, but I think all of these preceded this.

I don't have the official exhibits here, if you want to check a date here.

XQ. If you wish to refer to copies of the patents, please do so. A. In 1940, the one by Anxionnez had a thrust reversal concept and I'm sure a lot of people had thought of this idea. This is 1940.

XQ. Was thrust reversal of a jet engine known earlier than 1940? A. It would have to be known sometime before he put out the patent. He had to conceive it before he went to the Patent Office.

I don't know what you mean, how far back. I am sure [408] we talked about thrust reversals early, yes. One of the problems of the aircraft, even after you hit on the runway, so you'd like to immediately brake it some way.

That's not in flight, now, we are talking about on the runway.

XQ. Is there a difference? A. Oh, considerably.

The airplane that you are going to observe on Thursday can reverse the thrust in flight. They can even fly the plane backwards. You could do that with the concept that is in the patent in question. The principles are the same. You probably won't fly them backwards with the thrust reversal. You might drag them backwards on the ground.

Mr. Russell: To clarify the record, your Honor, I'd like to ask the witness when he said "the patent in question," to tie that meaning, the Douglas patent, Exhibit 4 in suit.

The Witness: Well, that's what I understood was the one in question.

Am I saying what exhibit number it is?

Mr. Russell: Exhibit 4.

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[413] which if you could take your finger and were strong enough you could support the aircraft.

XQ. Would that be the center of gravity? A. Yes.

XQ. The point you are referring to corresponds to the center of gravity, I take it? A. Not necessarily. I am adding on to that the drag resistance which is nil when you start the takeoff, but then you asked me about rotating it.

By the time you rotate it you better be having some speed or once you rotate it you are going to go in some other direction unless it is in the center. Of course, if you rotate it then it forces you to go some other direction.

XQ. Now, in talking about rotating nozzles, are you thinking about the Pegasus engine or the disclosure of the Douglas patent? A. I am talking about a principle. I said yesterday that the principle in the Pegasus engine, and as I interpret the patent, are identical in principle. But it won't—any other thing, just as long—in fact, we had one this morning here—was it Harris? I don't believe it was—Higby's, if it went through the center and he had enough thrust it would be—you could pivot that. I don't believe his does.

* * *

[424] control, retard, accelerate. That means you could use them for controls.

This could not be their main jet unless he was showing more than I see in the picture. So this had to be auxiliary in my interpretation.

The only reason for auxiliary aspect, I would say, would be for controls. I don't know whether Douglas thought about this that way. That's the way I interpret it now.

* * *

[432] about previous things where they did have concern with duct losses right in about the first two or three paragraphs of his patent.

Anytime—one of the things you have got to watch is not

to lose the energy you are putting in. You put it in in the form of pressure and if you start to use the pressure for velocity, the faster you go, you have rubbing and then you get your eddy currents, what we call a drag along the surface, or resistance.

XQ. When you say "big losses," — A. I just don't think this thing would have ever been a practical thing to fly with the cold air. I don't think you have enough energy there to take off. You can deflect the order of magnitude of losses even if you had 100 percent.

I don't believe that this would have been a working situation. I think this was a dreamer. We all are.

XQ. I direct your attention now to the Harris patent. A. The Harris patent, yes.

XQ. Defendant's Exhibit 25. A. Yes.

* * *

DENNING

Direct Examination

[652] which were necessary to be overcome in order to keep the hot thrust as near to the center of gravity of the engine as possible; and this meant that the—that the trouser piece duct turns very rapidly as it comes out of the engine in order to keep the hot nozzles as far forward as possible. That itself was a major problem of aerodynamics on the trouser piece and nozzle system.

Q. When was the first conceptual design in your company made of a jet engine having rotatable nozzles for vectoring combustion gases? A. Approximately the year 1967, January—'57, January of '57.

Q. When did your company arrive at the first conceptual design of a ducted fan engine with four rotatable nozzles, two for cold air from the forward fan section and two rotatable nozzles for vectoring hot combustion gases? A. On or about January, 1967 — '57.

* * *

LANCASTER

Further Cross-Examination

[711] A. Oh, I'll admit—and it hasn't come out here, but I met Dr. Hooker, and he's a brilliant person. Any time —I think this was the point of the question a while ago that you objected to that in any new design there are always new problems, and all I have indicated that I thought this patent referred to the principle involved, a concept that had not been thought of previously in sufficient detail to get a patent on it. I think I indicated in my earlier testimony many of us had made suggestions as to various things for the vertical take-off. But we hadn't gone to the trouble to write it down. Surely in the design of any new aircraft, it is at least five years usually from the bread board stage until you get an airplane flying. I believe in the case of this particular engine, according to my records, it did—it was in operation and produced its required thrust two years after the initial inception. Now the two years could vary as much as 11 months, I suppose, because of the date issue. This was started in January and my two years time may have been—it was in '59, anyhow, when it delivered its thrust, first operated.

Mr. Townsend: I have no further questions, your Honor.

The Commissioner: Mr. Russell?

DENNIS

Cross-Examination

[798] XQ. How about forward? A. I can't tell you how far the particular aircraft designer intended it because the drawing isn't detailed enough to show that.

XQ. So it's a fact, isn't it, that although the exhibit is specific to angles 60 and 77, there is no showing that it does or does not go beyond? A. That's correct.

XQ. And so your testimony yesterday that it would go

no more than 60 to 77 degrees is not correct, am I right? A. I—

Mr. Townsend: Objection, your Honor. That's not what the witness testified to yesterday. I would like to be able —plaintiff's counsel has been getting daily copies. He should refer to the specific place on the record.

Mr. Russell: If that goes on the record I want it noted that plaintiff's counsel has had daily copy only of a small portion of plaintiff's testimony, and he hopes to have another small portion, including this particular thing tomorrow—after lunch, excuse me.

The Commissioner: I think your question assumes a fact. Do you have any copy which would indicate that that is in fact what the man testified to?

Mr. Russell: I have my notes which says that the

* * *

[816] From what he concluded, if there was any pivoting of the engine beyond slight pivoting, it would have to be done with pivoting the whole engine. Do you recall that? A. I recall that, yes.

XQ. Don't you agree with him? A. No.

XQ. How can that be pivoted without pivoting the whole engine? A. It could be pivoted on the ducts which are marked with—I think it's F—so as you come out of the impeller you could have a—you can have a bearing at that point and rotate the whole duct and the hot pressure duct as well with some flexible fuel lines.

XQ. That would require a redesign of this piece of equipment, wouldn't it? A. Well, there's nothing shown in the diagram at all as to how the deflection of the ducts, K, is supposed to take place anyway.

XQ. It's described as done with a trunnion. A. It's described in the text, yes.

XQ. Where would you put a trunnion in trying to accomplish what you say you accomplish with the duct, F?

A. I don't know whether I would use a trunnion if I were using—if I were turning the duct at the point I have [817] just suggested.

I'd just have to go and think about that.

XQ. It's not altogether obvious to you at the moment as to just how you would do it. A. No, but it's not impossible to conceive of a way of doing it, I suspect.

XQ. Now, your previous testimony, without digging it out—I have it here—let's see if I can avoid the time of digging it out—I understood that you stated that the tube, K, would be mounted in the line of flight, is that correct? A. Yes.

XQ. Now, I wanted to clarify or at least find out what the purport of your previous testimony was about the composite exhibit, 26-A.

Mr. Russell: Do you know where that is, Mr. Townsend, so we could give it to the witness?

Mr. Arseneau: Should be on the reporter's table.

Mr. Russell: Here we are, 26-A.

By Mr. Russell:

XQ. Now, I take it that the tube K, is mounted in the line of flight which is horizontal. Do you agree with that? A. Are you referring to the composite sketch?

XQ. Yes, the composite sketch. A. Yes.

* * *

MASON

Direct Examination

[1036] A. To my knowledge, it was approximately a million dollars apiece.

Q. Was it necessary after the 25-hour life to overhaul these engines? A. Yes.

Q. Do you know the approximate cost of such an overhaul? A. To the best of my knowledge, it was in the neighborhood of a hundred thousand pounds, which at

the exchange rate, in those days would have been about $280,000.

Q. Now, approximately how many hours of flight were required by the Air Force to check out your experimental test pilots in the Kestrel? A. We gave them about three to four hours, at the time I was checking pilots out on the aircraft.

Q. Translating that three to four hours of flight time into engine wear, what would be the approximate cost to the United States of just checking out a pilot on the Kestrel? A. Well, if we consider the cost of a new engine, approximately $120,000. The cost of an overhauled engine, or at least the overhauled cost, I suppose, very quickly that would be $30,000 or $40,000, if my arithmetic is correct.

• • •

MR. W. E. P. JOHNSON:
Direct Examination

[18] to the plane of the wing for directionally controlling the discharges of the gases and in at least one position the effect of braking reaction. I would like to ask you this. When I asked you before were you aware of any art in 1946 disclosing the Douglas idea, I want to now be more precise and say disclosing what I have outlined as claim 1? A. I cannot recall knowing any such devices at that time. We are talking rather specifically about this claim, the aircraft, are we not? This is a claim which involves amongst other things—

Q. Apparatus for controlling— A. For controlling the reaction of propelling jets in a dirigible aircraft. The answer on that basis is no.

Q. Will you state, Mr. Johnson, whether or not you have an opinion with respect to whether Mr. Douglas' idea as depicted in claim 1 was obvious in 1946 to the man having ordinary skill in the jet propulsion art? A. Yes, I would gladly give you my opinion on this matter which is the same as it was then, that it was not obvious. I would not have been impressed by it if it had been obvious nor would my technical colleagues in the company.

Q. Do you know whether or not it was a practical suggestion? A. I would say it was, possibly not precisely in the form in terms of hardware that Douglas had in mind at that time, but as a concept, an inventive concept, I should say certainly.

Q. Is there any proof of that? A. I should say the proof resides in the fact the idea has since

* * *

[27] A. Undoubtedly, because the patent in suit sets out as one of its objectives to have a braking effect and any forward pointing vector has a braking effect more or less according to the angle.

Q. Therefore a small angle forward is— A. That is completely born out by the words used in Exhibit 6. I have just noticed it. I am not very familiar with this document. "The simultaneous angular movement from horizontally backwards to vertically downwards and perhaps to a small angle forward of the vertical should be adequate for all anticipated manoeuvres". The point of the small angle forward is to get a certain amout of arresting or backward thrust. When you consider that you want to land these things in a VTOL condition you have to be able to manoeuvre them that is to say, if you slightly overshot your target you have got to be able to get a small backward vector in order to reposition yourself.

Q. Going back to the claim, "Any plane substantially perpendicular to the plane of the wing". A. Yes.

Q. That is referring to the movability of the discharge conduit? A. So I understand it.

Q. Can you state from these photographs and drawings before you whether or not the axis of rotation conforms to the language of this claim. A. Yes. What we are talking about is the plane of movement rather than the axis. The words of the claim are, "in a plane substantially perpendicular to the plane of the wing".

* * *

[33] A. Correct.

Q. Were you aware in 1946 of any public use or sale of structure answering to claim 1 of the patent in suit? A. No, I am not aware of it, and I was so intimately knowledgeable in this art that I am quite sure there was not any. I do not think there was anything that went on that I did not know about. That is not a vain remark but because I was placed that way.

Q. You said in that last answer "known" and I suppose you meant to include used publicly or sold? A. Yes; broader than used publicly or sold, outside those circles

where there was some defensive secrecy or something of that kind. In my own circuit it was certainly not known, but what was going on in other countries I cannot say. I am not a professional spy so I cannot tell you that.

(*Adjourned for lunch*)

Q. During the lunch break you were explaining to me that you understood the meaning of the word "operational" as applying to the suitability for military operations? A. That was the way I took your question.

Q. However, I would now give you the question in the sense I intended. Do you have an opinion as to whether the equipment described in exhibits 6 and 7 is a viable equipment? A. Certainly it is; it has proven to be.

Q. What do you mean when you say "viable"? A. I would say it does the job it is intended to do, does it with sufficient reliability to be airworthy and it is competent in terms of weight and fuel consumption, and that makes a viable [34] aircraft engine to me. Perhaps I might explain that before lunch when you put the question to me about "operational", I do not think you were quite aware of the fact that you were using a word that is a vernacular term in this country, and that is why I stumbled over my answer. There was no doubt about its operability. Operational to me, at least as far as a military engine is concerned, means has it ever gone operational, has it ever flown, wherever it may be, on operations. I think I misunderstood you completely.

Q. Have you read with some care the specification of the patent in suit? A. Yes, I have.

Q. Do you have an opinion as to whether it is a sufficient teaching for a man skilled in the art to practice the claimed invention? A. I have no reservations at all about that. I would say anybody skilled in the art at that time could have picked up this specification and produced a viable result.

Q. Have you had occasion to look at the defendant's answer and in particular paragraphs 16 and 17? A. Yes, I have. It has only been a fairly short time but I have had time to look at it.

Q. What about the references cited in those two paragraphs? A. I have read all the references that are cited and as a matter of fact I think I was familiar with them all before.

Q. When you say "before" you mean—

• • •

11 X 12

APPENDIX J

PATENT SPECIFICATION

Application Date: Jan. 16, 1930. No. 1521/30. 347,203

Complete Left: Oct 16, 1930.

Complete Accepted: April 16, 1931.

PATENT OFFICE JUN 1 31 LIBRARY

PROVISIONAL SPECIFICATION.

Improvements relating to the Propulsion of Aircraft and other Vehicles.

I, FRANK WHITTLE, of Glenhaven, Regent St., Coventry, British Subject, do hereby declare the nature of this invention to be as follows:—

This invention concerns improvements relating to propulsion and whilst at present it is deemed to be particularly adapted to the propulsion of aircraft, it is not necessarily limited to this use and may be adapted for the propulsion of other vehicles.

The main object of this invention is to provide means whereby the principle of obtaining propulsive force in the one sense of direction by the reaction caused by expelling fluid in the opposite sense of direction, may be applied efficiently to aircraft or other vehicles.

It is believed that an embodiment of this invention will provide a large thrust in proportion to its weight, that it will perform at greater altitudes than are at present obtainable, that it makes possible higher speeds than have up to the present been obtained, that it will operate with any fuel now in use, and that it will have a reasonably low fuel consumption. Further that simplicity and convenient external form is achieved.

According to the invention, a heat cycle is employed, consisting of one or more stages of compression, one or more stages of expansion and a heat addition between the end of compression and the beginning of expansion, part of the work done in expansion being employed to do the work of compression, and the remainder to provide the fluid reaction.

Describing the invention in a simple form as applied to aircraft, there is a compression apparatus, consisting of a compressor, which may be a blower type compressor, a cylinder compressor, or a combination of the two, by means of which air as the working fluid is compressed into a heating chamber where heat is added by the combustion of fuel. The air then expanding through apparatus designed to absorb sufficient of the work of expansion to drive the compressor, and which may consist of a turbine rotor, or cylinder expander or a combination of the two, and which is on the same shaft as, or connected with the compression mechanism. The air then passes through a suitably designed tunnel to the atmosphere, either having velocity as a result of its passage through expansion apparatus, of being capable of further expansion through suitably designed nozzles at the rear, or both.

In another form, a portion of the air only may expand through the expansion apparatus which drives the compression apparatus, and the remainder expands to the atmosphere providing fluid reaction.

In more particularly describing the invention in an aircraft adaption, I propose to use a centrifugal rotary vane blower or turbo-compressor as a compressor. The air intake is a tunnel situated in the nose of the aircraft and leading in an axial direction to the inlet orifice of blower. The gas is passed circumferentially through suitably designed passages or diffusers into the heating chamber, which is of suitable material, and probably lagged externally to conserve heat. Into this chamber are directed burners for oil fuel and any further necessary details of construction such as pilot burners, cleaning devices etc. At the rear of the heating chamber the gas passes through suitable nozzles to impinge on the buckets or blades of a De Laval or Curtis type turbine wheel, the latter being mounted on the same shaft as the compressor. The gas passes into a tunnel after leaving the turbine and is led to the rear, where the final stage of expansion to the atmosphere takes place through suitably designed nozzles.

The invention is not limited to the mechanism detailed above. For instance, instead of the air passing through apparatus for driving compressor after heating, it may pass through and give up some of its heat to the water in a steam boiler, the steam so generated being utilised to drive the compression mechanism by means of a steam turbine or other steam engine. This would then be a substitute for the gas turbine above specified.

Controlling means may include fuel control, gas flow control, or mechanical control of the speed of the blower and/or

[*Price* 1/-]

its mover. The final emission of gas may perhaps be directionally controlled for manœuvring purposes. One or a plurality of the complete power units may be provided in a single vehicle or aircraft and they may to some extent be interdependent, e.g. a single turbine may operate subsidiary blowers etc.

It may be necessary to provide auxiliary apparatus for starting, fuel injections, lubrication or like purposes.

It will be clear that the invention gives scope for wide modification without departing from its principle as herein outlined.

Dated this 14th day of January, 1930.

F. WHITTLE.

COMPLETE SPECIFICATION.

Improvements relating to the Propulsion of Aircraft and other Vehicles.

I, FRANK WHITTLE, late of "Glenhaven", Regent Street, Coventry, and now of "Hill Crest" Dorrington, Lincoln, British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to apparatus for propulsion of the type in which air is taken in, compressed, heated, and expelled with high velocity on re-expansion in order to provide a propulsive thrust.

The main object of this invention is to provide improved apparatus of the above mentioned type, and in particular improved means for driving the compressor.

According to the invention I provide means for propulsion of the above mentioned type characterised by the feature that the compressor is driven by a turbine, and that the pressure drop on expansion takes place in two stages, the first pressure drop taking place through the nozzles of the turbine, and the second pressure drop taking place through the propelling nozzles.

Describing the invention in a simple form as applied to aircraft, there is a compressor, preferably of the turbo-centrifugal type, by means of which air as the working fluid is compressed into a heating chamber where heat is added by the combustion of fuel. The air is then expanded through apparatus designed to absorb sufficient of the work of expansion to drive the compressor, and which consists of a turbine rotor, and which is on the same shaft as or connected with the compressing mechanism. The air then passes through a suitably designed tunnel or nozzles to the atmosphere, either having velocity as a result of its expansion through the expansion apparatus, or being capable of further expansion through suitably designed nozzles at the rear, or both.

The invention will now be described with aid of the accompanying drawing and diagram in which:—

Fig. 1 is a diagram showing the cycle of energy or thermal cycle on which the invention relies fundamentally.

Fig. 2 is a part-section showing diagrammatically a preferred form of the invention, applicable to the propulsion of aircraft.

The thermal cycle employed which is shown in Fig. 1 is a pressure-volume diagram in which:

AG represents the atmospheric line.

DC represents compression.

CE represents heating at constant pressure.

EF represents that portion of expansion which is utilised to do the work of compression.

FG represents the expansion to the atmosphere providing thrust by fluid reaction.

The device consists of a compressor having casing "1" inlet [illegible] a rotor "3", with bucket rings "4" working in conjunction with [illegible] bucket or nozzle rings "5" inside the casing "1" and centrifugal [illegible] bleeding "7" and diffuser "8" [illegible] which the output is delivered under pressure through header or [illegible] "9" into combustion or heating chambers "10" in which fuel is burnt. This may be heavy oil or other fuel injected at jets "11". The chambers "10" are preferably lagged or otherwise heat insulated to conserve heat energy, and perhaps lined with refractory material. The heated gases pass into a collector or header "12" from chambers "10" which are of any suitable number and disposition. From header "12" the gases expand through a turbine "13" with buckets "14" and stator "15", the turbine rotor "13" being fast on the spindle "16", which is also the driving spindle of the compressor rotor "3",

BLURRED C

'7". From the turbine the gases further expand through nozzles "17" to the atmosphere in an axial direction.

Any suitable type of turbine may be used, but in order that the relatively high temperature proposed to be employed may be withstood, the buckets may be of some suitable refractory material.

The turbine drives the compressor direct as shown, but direct drive is not essential, any gearing or the like may of course be employed.

The air entering at "2" is first of all compressed by the bucket system "4" "5", and by blades "7". In the chambers "10" the air is heated at constant pressure and expands through the turbine "13" losing energy by driving the turbine and compressor. Its remaining pressure and velocity energy is then converted into velocity out of the nozzles "17", whereby reaction in the nature of axial thrust is set up according to the usual laws.

It can be demonstrated that the efficiency of this device conceived as a propulsive engine, will not be reduced by reduction of the density of the atmosphere, and owing to the low temperature of the upper atmosphere may actually be enhanced.

Controlling means may include fuel control, gas flow control, or mechanical control of the speed of the blower and/or its mover. The final emission of gas may perhaps be directionally controlled for manœuvering purposes.

It may be necessary to provide auxiliary apparatus for starting, fuel injections, lubrication or like purposes.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Means for propulsion of the type described, characterised by the feature that the compressor is driven by a turbine, and that the pressure drop on expansion takes place in two stages, the first pressure drop taking place through the nozzles of the turbine, and the second pressure drop taking place through the propelling nozzles.

2. Means for propulsion according to Claim 1, in which a multi-stage turbine is employed.

3. A propulsion device in which a centrifugal turbo-compressor supplies compressed air to a heating chamber whence the air passes to drive a turbine which mechanically drives the compressor, and whence in turn the air and products of combustion escape to the atmosphere through passages which cause them to produce propulsive thrust.

4. A device according to claims 1 and 3, constructed and operating substantially as described with reference to Fig. 2 of the accompanying drawings.

Dated this 14th day of October, 1930.

F. WHITTLE.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1931

OPY

347,203 COMPLETE SPECIFICATION 1 SHEET

[This Drawing is a reproduction of the Original on a reduced scale]

FIG. 1.

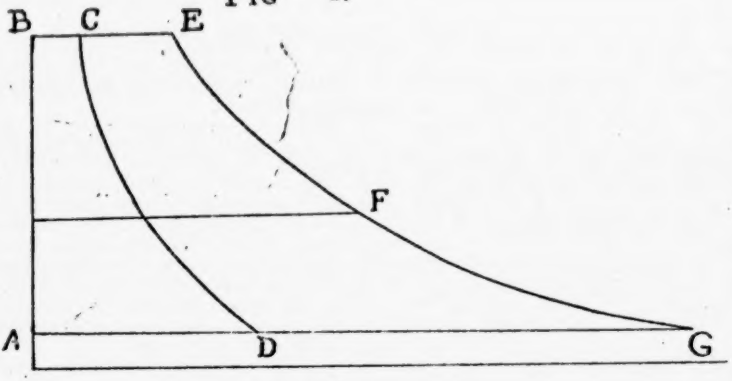
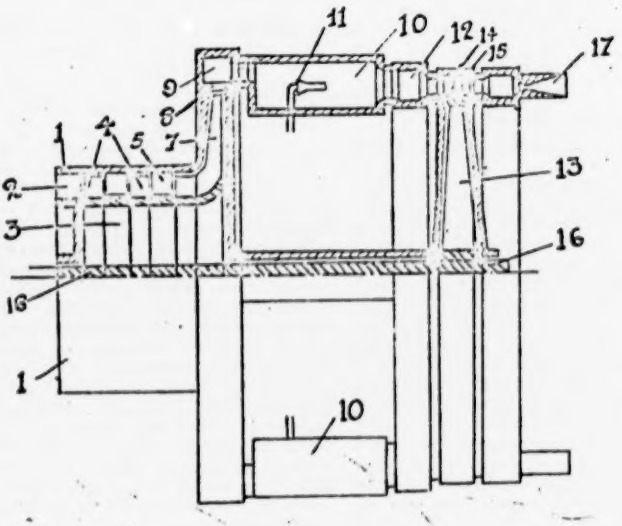


FIG. 2.



Charles & Read Ltd. Photo Litho

U. S. PATENT OFFICE
PAPER NO. 9
JUN 10 19[illegible]

FRASER, MYERS & MANLEY
ATTORNEYS AND COUNSELLORS AT LAW
100 BROADWAY, NEW YORK 6, N. Y.

(14275)

DIVISION 22

IN THE UNITED STATES PATENT OFFICE

Applicant : Aubrey Douglas
Invention: Jet Propulsion and Control Means Therefor

Div. 22 *Room No.* 5724
Serial No. 695,839
Filed September 10, 1946

AMENDMENT
(3)

Hon. Commissioner of Patents,

Washington, D. C.

Dear Sir:

In response to the official rejection of December 19, 1950, kindly amend the above-entitled application as follows:-

SPECIFICATION:

Page 4, line 20, after the period, insert .. The reactionary effect generated by the diversion of the jet should pass through the proximity of the center of gravity of the aircraft, i.e., through a point between the leading and trailing edges of the wing. However, in the case of a strongly swept-back wing, the center of gravity of the aircraft might be situated slightly to the rear of the wing roots, i.e., outside the wing contour. Accordingly, it might be said that the reactionary effect generated by the diversion of the jet should pass through a point between the leading and trailing edges of the theoretical aerofoil as projected onto the plane of symmetry of the aircraft. ..

CLAIMS:

Claims 24, 25 and 26, line 2 of each, next before "means" insert .. valve ..; last line of each, next be-

fore the period, insert .. depending on the direction of the discharge conduit ..

Claim 24, line 8; claim 25, line 9; and claim 26, line 8, after "a" insert .. forward and lifting, a lifting, a braking and lifting or a ..

Claim 24, lines 8 and 9; claim 25, line 9; and claim 26, line 9, cancel the phrase "or lifting"

Claim 29, line 1, delete "24" and substitute .. 26 ..

Claim 32, line 10, after "a" insert .. forward and lifting, a lifting, a braking and lifting or a ..; same line, erase "or lift"; last line, next before the period, insert .. depending on the direction of the discharge conduit ..

Claim 34, line 7, after "arc" insert .. of more than 90° with respect to the normal direction of flow of the gases through the jet tube ..; line 8, cancel "propelling, braking or lifting" and substitute .. forward and lifting, a lifting, a braking and lifting or a braking ..; last line, next before the period, insert .. depending on the direction of the discharge conduit ..

Add the following claims:-

36. Apparatus according to claim 24 wherein the reaction generated by the diversion of the jet passes through a point between the leading and trailing edges of the wing.

37. Apparatus according to claim 24 wherein the reaction generated by the diversion of the jet passes through a point between the leading and trailing edges of the theoretical aerofoil as projected onto the plane of symmetry of the aircraft.

REMARKS

In response to the Examiner's requirement for elec-

A-125

FOL-90

ADDRESS ONLY THE COMMISSIONER OF PATENTS WASHINGTON 25, D. C.

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE
WASHINGTON

PAPER NO. 10

ALL COMMUNICATIONS RELATIVE TO THIS APPLICATION SHOULD GIVE THE SERIAL NUMBER, NAME OF ITEM, AND NAME OF THE APPLICANT

MAILED

Remington/vm

Please find below a communication from the EXAMINER in charge of this application.

John A. Marzall OCT 3 1951

PATENT EXAMINING DIVISION

Fraser, Myers & Manley
165 Broadway
New York 6, N. Y.

Commissioner of Patents

Division: 22 - Room 5724 22
Applicant: Aubrey Douglas
Ser. No. 695,839
Filed Sept. 10, 1946
For JET PROPULSION AND CONTROL MEANS THEREFOR

FINAL REJECTION

Responsive to amendment filed June 16, 1951.

Cancellation is required of the insertion which is directed for entry on page 4, line 20, after the period. The subject matter of this insertion is not a part of the original disclosure filed more than five years ago, and applicant cannot be permitted now to enlarge the disclosure in this manner by adding afterthoughts of this nature.

Claims 24 and 25 are rejected on Meyer in view of Campini. Meyer discloses a jet tube and means for diverting the flow of the combustion gases. To employ a valve means for causing the diversion would not amount to invention in view of Campini since Figures 26 and 27 of this patent illustrate valves for diverting flow of a jet. It is noted that the statement of function at the end of the claims has been amended, but this fails to make the claims allowable because statements of function cannot be relied upon to distinguish over the prior art.

Claim 24 is additionally rejected on any one of Gazda or Lysholm, each in view of the valve illustrated in Figure 26 of Campini. There would be no invention in employing a valve such as that of Campini at the position of 26 of Gazda or 100 of Lysholm whereby the diverted gases would be caused to move through a discharge conduit as at 7'.

44

Ser. No. 695,839 ---- 2

Claim 26 is rejected on Lysholm in view of Campini. In Figure 2, Lysholm discloses a jet tube 52, valve means 100 96 and 98. These valve means divert the flow of combustion gases from normal, and it is considered that in view of Campini's teaching of valve means as illustrated in Figures 26 and 27 for diverting flow of a jet to associated conduits similar to 92 and 94 of Lysholm, no new result amounting to invention would be produced by employing valve means as claimed. The statement of function in the last part of the claim defines no structure; however, Lysholm anticipates the functions in the statement on page 4, column 2, lines 7 to 11, of his specification.

Claim 29 is rejected as claim 26 from which it depends with the further observation that the Campini discharge conduit outlet is movable angularly with respect to the normal direction of flow of the jet - see Figure 26, and if any weight could be given to a mere statement which stands without recitation of structure that would provide for angular movement, then the Campini disclosure would offset such weight.

Claims 30 and 31 are rejected on Meyer in view of the disclosures of Campini and Lysholm. The grounds of rejection are, in general, the same as stated in the rejection of claim 24 from which these claims depend. Lysholm is added as disclosing the idea of positioning the jet conduit outlet where it will produce a braking or lifting reaction. In view of the teaching of Lysholm, it is considered that no invention would be required to direct the jet of the Meyer system through the underside of the wing by valve means such as that of Campini.

Ser. No. 695,839 ---- 3

Claims 32 to 34 are rejected on Lysholm in view of Valdes or Gazda. Lysholm in Figure 2 discloses a baffle 100 movable across tube 52, a duct 92 or 94 and means 96 and 98 for selecting the direction of diverted gases. It is considered that after the disclosure of Valdes at Fig. 7,or Gazda, 18', each of which shows a conduit associated with the outlet end of a duct which conduit is directionally controllable, no invention would be required to employ such a controllable discharge conduit on either one or both of ducts 92, 94 of Lysholm. As to claim 33, it is considered that ejector action would be present but, in any event, the claim defines no relationship of inlet and outlet which would constitute an ejector means. The mere statement that there is an ejector means defines no structure.

Claim 36 is rejected on Meyer in view of Campini and Lysholm for the same reasons as claims 30 and 31. It is considered that merely to substitute a power plant such as that of Lysholm for the power plant of Meyer, thereby positioning the diversion reaction between the leading and trailing edges, would not amount to invention.

Claims 27, 28 and 35 are directed to the non-elected species of Figures 3 to 11, and are rejected as not properly claimable in this application.

Claim 37 is rejected as being directed to features not originally disclosed, and therefore claiming new matter. It is rejected for this reason.

Claims 1 to 23 are cancelled.

No claim is allowed.

A clear issue has now been reached, it is believed, and therefore this rejection is made FINAL. The art cited against the claims has been previously used in this application.

Rem.

Examiner

A-128

FRASER, MYERS & MANLEY
ATTORNEYS AND COUNSELLORS AT LAW
165 BROADWAY, NEW YORK 6, N. Y.

(14275)

IN THE UNITED STATES PATENT OFFICE

Applicant :	Aubrey Douglas	*Div.* 22	*Room No.* 5724
Invention:	Jet Propulsion and Control Means Therefor	*Serial No.*	695,839
		Filed	September 10, 1946

AMENDMENT
(4)

Hon. Commissioner of Patents,

Washington, D. C.

S i r:

In response to the official letter of October 3, 1951, kindly amend the above-entitled application as follows:-

DRAWINGS:

Cancel Figs. 3, 4, 5, 6, 7, 8 and 14. Renumber Figs. 9, 10, 11, 12 and 13 as Figs. 3 to 7, respectively. A separate communication is being addressed to the Official Draftsman requesting that the Fig. designations be changed as indicated in the preceding sentence.

SPECIFICATION:

Page 2, cancel lines 18 through 26, inclusive; line 27, cancel numerals "9, 10, 11" and substitute numerals .. 3, 4, 5 ..; line 28, after "cross-section" insert .. along the line 11-11 of Fig. 4 ..; same line, after "respectively" insert .. of ..; line 30, cancel numeral "12" and substitute numeral .. 6 ..; last line, change "Fig. 13" to .. Fig. 7 ..; same line, change "Fig. 12" to .. Fig. 6 ..

Page 3, cancel lines 1 to 4; line 14, cancel "nozzle" and substitute .. jet tube ..

Serial No. 695,839.

Page 4, line 20, cancel the amendment inserted after the period in this line; cancel lines 26 through 34, inclusive.

Page 5, cancel lines 1 through 13, inclusive; line 14, cancel numerals "9, 10, 11" and substitute numerals .. 3, 4, 5 ..; line 17, change "Fig. 10" to .. Fig. 4 ..; line 19, change "Fig. 9" to .. Fig. 3 ..

Page 6, line 2, change numeral "11" to .. 5 ..; line 8, change numerals "12 and 13" to .. 6 and 7 ..; cancel lines 22 through 33, inclusive ..

Page 7, cancel lines 1 through 3, inclusive.

Page 8, cancel lines 16 through 30, inclusive.

CLAIMS:

Cancel claims 24 to 37, inclusive, without prejudice, and substitute in lieu thereof the following claims:

1. ~~38. (Substitute for claim 25)~~ Apparatus for controlling the reaction of a propelling jet in a rigid wing aircraft, comprising a jet tube mounted approximately parallel to the line of flight, means for diverting the flow of at least part of the combustion gases from the jet tube to cause them to move in a direction other than normal, a discharge conduit associated with the jet tube adapted for receiving the diverted gases, the discharge outlet of said discharge conduit being selectively movable about an axis in an arc of approximately 180°, in a plane substantially perpendicular to the plane of the wing for directionally controlling the discharge of gases from the conduit to effect, in at least one position of the discharge conduit, a braking reaction on the aircraft.

2 ~~39.~~ Apparatus according to claim ~~38,~~ 1 wherein in at least another position of the discharge conduit, a braking and lifting reaction on the aircraft is effected.

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113,123

PATENT SPECIFICATION

Application Date, Aug. 16, 1917. No. 2361/17.
Complete Accepted, Aug. 16, 1918.

COMPLETE SPECIFICATION.

Improvements in or relating to Engines or Motors.

I, HERBERT STOCKER HARRIS, of Buckland House, Esher, in the County of Surrey, Surgeon, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to engines or motors of the kind in which the combustion of a suitable fuel is utilised to produce a gaseous stream for propelling or driving purposes. For example such motors have been suggested for use on aircraft, in which case the gaseous stream is discharged into atmosphere to cause by reaction the propulsion of the aircraft. Motors of this kind have also been proposed for other uses in which a mechanical element such as a turbine rotor has been actuated by the gaseous stream. In a prior proposal the fuel is introduced under high pressure and on issuing in the form of a stream from a combustion chamber is allowed to expand in a tube having an open end surrounding the combustion chamber the diameter of the said tube increasing towards the outlet or discharging end; the expansion it is stated causes the air to be introduced into the tube through the said open end surrounding the combustion chamber to mix with the gaseous stream and by means of a series of baffle plates the speed of the stream is diminished and the mass augmented.

The chief object of the present invention is to avoid expansion of the gaseous stream on entering the discharging tube as it is found that the stream in expanding produces eddy currents adjacent to the nozzle from which the stream issues, and thereby prevents or hinders the entry of air into the discharging tube thus, reducing the efficiency of the motor.

According to my invention, the gas issues from the combustion chamber into the discharging tube at atmospheric pressure or thereabouts in the form of a stream which is of parallel or cylindrical form that is to say it does not expand, so that on cooling and contraction in the discharging tube a partial vacuum or suction effect is produced that induces the inflow of air which freely enters and mixes with the gaseous stream thereby increasing the mass of the latter. The discharging tube may be made of fairly considerable length and owing to the continued cooling of the stream throughout the tube and the consequent decrease in volume of the air and gas the tube is tapered towards its discharging end so as to reduce its cross sectional area. The length of the tube should be such that the gaseous stream is completely cooled at the discharging end to prevent any suction effect at that end and the entry of air in the direction opposite to the direction of flow. Additional air may be introduced at several points along the discharging tube in any suitable or convenient manner

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for further augmenting the mass of the gaseous stream. The combustion chamber is enlarged to allow for the expansion of the products of combustion and towards its discharging opening it is contracted slightly to increase the velocity of the gas which however as stated above does not expand after leaving the combustion chamber. By means of the present invention the mass or weight of the stream is considerably augmented and practically the whole of the heat of the stream is converted into kinetic energy. The fuel for the combustible charge may be of any suitable kind, for example, a liquid fuel such as petrol, paraffin or the like or coal dust may be used in any known or convenient manner.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be described more fully with reference to the accompanying drawings, in which:—

Figure 1 is a sectional plan of one embodiment of the invention suitable for use on aeroplanes.

Figure 2 is a front elevation, half of which is in section as viewed on the line 2—2 of Figure 1.

In the example illustrated, A is a tank for containing liquid fuel such as petrol; B B are pipes leading from the tank and terminating in suitable nozzles C C; D is a small petrol motor for rotating a fan E located in a casing F provided with an air inlet G shaped to form rearwardly extending tubular portions H H around the nozzles C C and having suitably shaped outlets J J such as shown in Figure 1.

A tube K surrounds each tubular portion H of the casing F and extends rearwardly for a suitable distance, both ends of each tube being open as shown in Figure 1. Petrol is supplied from the tank to the nozzles C and the rotary fan E drawing air through the inlet G delivers it at low pressure into the tubular portions H of the casing F; the petrol issuing from the nozzles C C mingles with the air supplied by the fan E thus forming the combustible mixture which on being ignited or burnt in the combustion spaces L L expands within the enlarged parts of the tubular portions H H and then passes through the slightly contracted outlets J J from which the gas issues at atmospheric pressure or thereabouts in substantial cylindrical form. The gas on cooling in the discharging tube K produces a partial vacuum which draws the air into the tube in the direction of flow and owing to the non-expanding stream issuing from the outlets J the entry of air is not impeded. Owing to the continued cooling of the stream and the consequent decrease in volume the discharging tube is made tapered towards its discharging end to prevent entry of air at that end. The tube should be long enough to ensure complete cooling prior to the stream reaching the discharging end from which the stream greatly increased in mass by the air, is discharged at atmospheric pressure or thereabouts. The mass of gaseous stream on being discharged at the rear end of the tubes into atmosphere and impinging on the air produces the reaction and propulsion of the aeroplane.

It will be understood that the example above described and illustrated in the drawing is purely diagrammatic and is only intended to show one mode of carrying the invention into effect. Several changes and modifications may be effected, for instance, it may be desirable to employ a series of nozzles or burners arranged in any convenient manner; additional air may be introduced at several points along the tubes K at successive stages.

Furthermore, it may be desirable to provide a single tube of large cross sectional area which may be used instead of two comparatively small tubes as shown. In this case one or more nozzles may be provided as aforesaid and the single tube may be so shaped or arranged at its forward part to provide accommodation for the pilot and a fuel tank and an engine such as D for driving a fan which delivers air under slight pressure to the combustion space or spaces.

Instead of supplying the air into the combustion spaces by a fan the arrangement may be such that a current of air is caused to flow through a suitable collector or deflector and to pass around the burners or nozzles to mingle with the petrol or the like supplied through the same. The current of air may be utilised for sucking the petrol or the like through the burners or nozzles, or the petrol issuing from the nozzle may draw in the air for combustion which will draw in additional air for increasing the weight of the discharged gas. For starting the engine a small propeller or fan may be provided in the tube for drawing in the air and petrol, or the like and the rear end of the tube could be partially closed for a time by a suitable valve capable of being readily operated to open the discharging end of the tube when desired. In a further modification a fan situated in the tube K and driven by the gas flowing through the latter may be coupled to a compression fan so as to drive the latter which delivers air required for combustion.

The tube or tubes such as K may in some instances be mounted in such a manner that the position thereof could be controlled for the purpose of varying the direction of discharge. For instance the tube may be angularly movable in a vertical direction on horizontal trunnions or pivots for enabling or assisting the aeroplane to rise or descend, and/or the tube may be movable laterally for enabling or assisting the aeroplane to turn. Normally of course the tube would occupy a position in which the aeroplane would be propelled horizontally in a straight path, and to change the movement of the aeroplane means may be provided to enable the pilot to readily alter the position of the tube as required. The tube may be moved to discharge the stream in the front of the aeroplane to produce a braking action and thus retard the speed of the aeroplane when landing. Instead of moving the tube for this purpose, the rear end thereof could be temporarily closed in suitable manner, so that the gas is discharged through the front end of the tube.

It will be understood that the invention is capable of being used for or in connection with the propulsion of vessels or vehicles other than aeroplanes and airships.

Moreover, the invention is applicable for use as a motor or engine in which a mechanical element is actuated; for example the aforesaid tube may be connected to a casing containing a rotary element having blades or vanes or the rotary element may be arranged in the cylinder the arrangement being such that the pressure of the gas on the blades or vanes effects the rotation of the said element thereby forming a gas operated turbine or rotary engine.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An engine or motor of the kind referred to, in which the gas issues from the combustion chamber into a discharging tube at atmospheric pressure or thereabouts in the form of a non-expanding stream so that air can be freely drawn into the discharging tube to mix with and increase the weight of the stream owing to the partial vacuum or suction effect produced by the cooling and contraction of the stream in the discharging tube.

2. An engine or motor as claimed in Claim 1, in which the discharging tube is of fairly considerable length compared with its transverse measurement at any point along the length and decreases in cross sectional area towards the discharging end, substantially as and for the purpose specified.

3. An engine or motor as claimed in Claim 1, in which additional air is introduced at several points along the discharging tube, substantially as and for the purpose specified.

4. An engine or motor as claimed in Claim 1, in which the combustion chamber is formed with an enlarged portion to allow for expansion of the products of combustion which enlarged portion is contracted towards the outlet of the combustion chamber, substantially as described.

5. An engine or motor of the kind set forth in any of the preceding claims in which the discharged gases are utilised to move a mechanical element, substantially as described.

6. An engine or motor having its parts constructed, arranged and adapted to operate substantially as hereinbefore described with reference to the accompanying drawings, for the purpose specified.

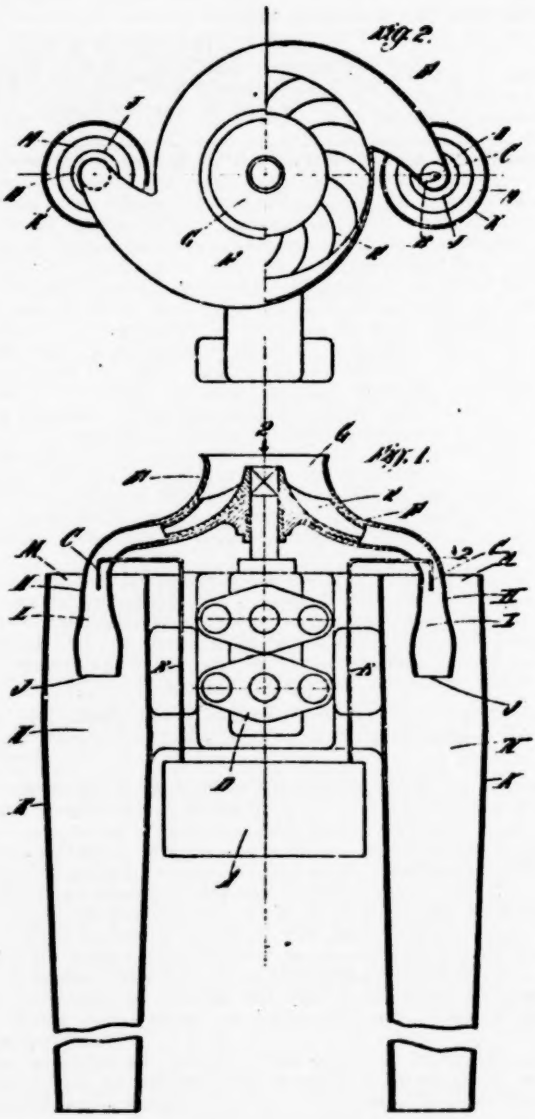
Dated this 16th day of August, 1917.

HASELTINE, LAKE & Co.,
28, Southampton Buildings, London, England, and
55, Liberty Street, New York City, U.S.A.,
Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1918.

118,123. HARRIS' COMPLETE SPECIFICATION. (1 SHEET)

[This Drawing is a reproduction of the Original on a reduced scale]



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#A

March 12, 1929. W. E. HIGBY 1,704,895

POWER SYSTEM FOR AIRPLANES, ETC

Filed Jan. 24, 1928

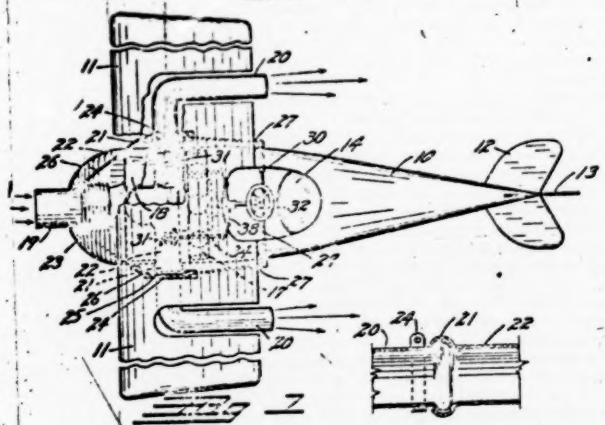

FIG 1

FIG 4

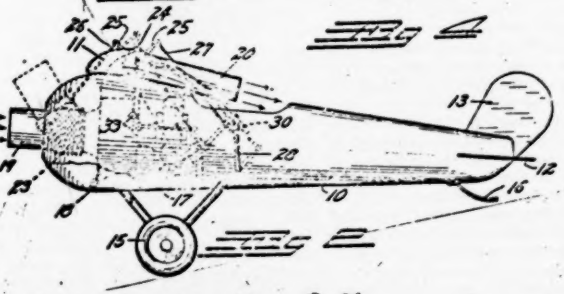

FIG 2

FIG 3

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Patented Mar. 12, 1929. 1,704,895

UNITED STATES PATENT OFFICE.

WILLIAM E. HIGBY, OF MONUMENT, COLORADO.

POWER SYSTEM FOR AIRPLANES, ETC.

Application filed January 24, 1928. Serial No. 249,091.

This invention relates to a method for propelling an airplane. It has for its principal object the provision of an airplane which will be propelled in the air or along on the ground by means of a blast of air projected from the plane.

Another object of the invention is to provide an airplane which will be guided both as to vertical and lateral direction by means of air blasts which are adjustable both for direction and intensity.

Other objects and advantages reside in the detail construction of the invention, which is designed for simplicity, economy, and efficiency. These will become more apparent from the following description.

In the following detailed description of the invention reference is had to the accompanying drawing which forms a part hereof. Like numerals refer to like parts in all views of the drawing and throughout the description.

In the drawing:

Fig. 1 is a plan view of an airplane in which my invention is embodied.

Fig. 2 is a side elevation thereof.

Fig. 3 is a detail view illustrating the control mechanism for the draft dampers.

Fig. 4 is a detail view illustrating the rotatable joint in the air blast pipes.

In the drawings, the various parts of a typical airplane are indicated by numerals as follows: fuselage 10, wings 11, vertical rudder 12, horizontal stabilizer 13, cockpit 14, wheel carriage 15, and tail skid 16.

Forwardly of the cockpit 14 any of the usual engines may be placed, as indicated at 17. This engine is employed to drive a centrifugal fan, the housing of which is indicated at 18. The fan 18 intakes from an intake pipe 19 which projects from the nose of the fuselage 10 and discharges through a pair of discharge pipes 20, one of which projects rearwardly from each of the wings 11.

The discharge pipes 20 each contain a rotatable joint 21, illustrated in detail in Fig. 4, so that their extremities, which are L shaped, may be rotated on the extremities of the short stationary portions 22 of the discharge pipe. The intake pipe 19 is provided with a bellows joint 23 which allows the forward extremity of the intake pipe to be turned from a position in alignment with the axis of the fuselage to an upwardly projecting angle, as indicated in broken line in Fig. 2. Any suitable joint may be employed in place of the bellows 23 such as a ball and socket, or loose sleeve joint if desired.

Adjacent the rotatable joints 21 in the discharge pipes fixed rings 24 are secured from each of which a pair of levers 25 project. The rearward lever 25 of each of the rings 24 is connected by means of a connecting rod 27 to a lever 28, one of which is placed on each of the extremities of a control shaft 29. The control shaft 29 may be turned by means of a control lever 30 which is placed conveniently to the operator in the cockpit 14.

By means of this arrangement, the projected blast of air can be directed at any desired rearward and downward angle and the air can be drawn inward at any desired forward and upward angle. Thus the blast can be used to assist in lifting the plane from the ground by directing it at a substantial downward angle. The lifting action is assisted by the intake pipe 19 which turns upwardly as the discharge pipes turn downwardly and creates a vacuum over the nose of the plane. As the plane reaches the desired height the intake and discharge pipes can be straightened by means of the lever 30 to a more nearly horizontal position where they will act to drive the plane forwardly, it depending then upon the wing section for its lift.

With this invention there is no need for a vertical rudder, merely a stabilizer 13 being provided. The lateral movements of the plane are controlled by varying the relative force of the blast in the respective discharge pipes 20. This is accomplished by means of blast dampers 31 which are placed in the short discharge pipes 22 and controlled in any desired manner from a steering wheel 32.

The damper control as illustrated comprises two pairs of bevel gears 33. One gear of each pair is placed on the extremity of one of the damper shafts, and the other gear of each pair being placed on one of a pair of short parallel counter shafts 34. The counter shafts 34 extends rearwardly and terminate in levers 35. On the extremity of the steering wheel shaft a lever 36 is placed. Push rods 37 extend from the levers 35 into contact with the lever 36 and are maintained in contact therewith by means of springs 38. Collars 39 limit the inward movements of the push rods.

By this arrangement, rotation of the steering wheel to the left causes the lever 36 to push on the left hand push rod and close the damper in the left hand blast pipe thus directing the majority of the air blast through the right

hand pipe which will act to swing the plane in a left circle. To turn in a right circle, the steering wheel is turned toward the right which allows the left hand damper to open and closes the right hand damper, thus creating a stronger blast in the left hand discharge pipe which swings the plane in a right circle.

The discharge pipes are for the most part concealed within the structure of the wings 11. To lessen the thickness of the wing the pipes can be made to have a cross section conforming to the shape of the wing, instead of round as shown, if desired.

The rotatable joint 21 may be constructed in any desired manner which will allow the L shaped extremity to be turned on the stationary portions 22. As illustrated, an annular bead is formed on the extremity of the portions 22 which slides upon a similar bead formed upon the L shaped extremities, as shown in Fig. 4.

While the invention has been described as particularly applicable to an airplane it is easily conceivable that it might be employed for driving and guiding other types of vehicles and it is desired to be understood that all such adaptions are within the conception of the invention.

While a specific form of the improvement has been described and illustrated herein, it is desired to be understood that the same may be varied, within the scope of the appended claims, without departing from the spirit of the invention.

Having thus described the invention, what I claim and desire secured by Letters Patent is:—

1. A power system for airplanes and the like comprising a motor; a fan driven by said motor; a housing surrounding said fan; an intake pipe to said housing opening forwardly of said airplane; a pair of discharge pipes for said housing, one of said discharge pipes being placed on each side of the longitudinal axis of said plane so as to direct an air blast rearwardly therefrom; means for simultaneously varying the angle of discharge of said discharge pipes and the angle of intake of said intake pipe.

2. A power system for airplanes and the like comprising a motor; a fan driven by said motor; a housing surrounding said fan; an intake pipe to said housing opening forwardly of said airplane; a pair of discharge pipes for said housing, one of said discharge pipes being placed on each side of the longitudinal axis of said plane so as to direct an air blast rearwardly therefrom; means for varying the angle of discharge of said discharge pipes; and other means for varying the angle of intake of said intake pipe, said two means arranged to operate simultaneously and in unison with each other.

3. A power system for airplanes and the like comprising a motor; a fan driven by said motor; a housing surrounding said fan; an intake pipe to said housing opening forwardly of said airplane; a pair of discharge pipes for said housing, one of said discharge pipes being placed on each side of the longitudinal axis of said plane so as to direct an air blast rearwardly therefrom; means for varying the angle of intake of said intake pipe and means for varying the angle of said discharge pipes, said means being arranged for manual control by the airplane operator and operatively connected so that said intake pipe will turn upwardly as said discharge pipes turn downwardly.

4. A power system for airplanes and the like comprising a motor; a fan driven by said motor; a housing surrounding said fan; an intake pipe to said housing opening forwardly of said airplane; and a pair of discharge pipes for said housing, one of said discharge pipes being placed on each side of the longitudinal axis of said plane so as to direct an air blast rearwardly therefrom; a damper in each of said discharge pipes and means for operating said dampers so that a greater blast of air can be discharged from either one of said pipes than from the other of said pipes, said greater blast acting to guide said plane; and means for controlling said dampers, said means comprising a system for transmitting mechanical motion and a steering apparatus manually operated to control said system; said steering apparatus comprising a steering shaft; a lever projecting from said shaft; push rods adapted to contact with each side of said lever; springs for maintaining said push rods in contact with said lever; and stops adapted to limit the inside movement of said push rods, each of said push rods being operatively connected with one of said dampers.

In testimony whereof, I affix my signature.

WILLIAM E. HIGBY.